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Thunderstorm, Cloudburst and Flood at Langtoft, East Yorkshire, July 3rd, 1892.

By JOHN LOVEL, F.R.Met.Soc.

(Plate I.)

[Received September 22nd.—Read November 16th, 1892.]

An unusually severe thunderstorm passed over the Wold district of East Yorkshire on Sunday evening, July 3rd, 1892. At the Society's Climatological Station, Driffield, observations were made as follows :—

The barograph trace, after having been low on the Tuesday night preceding, with a storm of wind from the North-east and nearly an inch of rain, had risen considerably during the week, but gave indications of an approaching change on the Friday midnight, when it commenced to fall steadily. On the Saturday a warm hazy sky prevailed, with light South-south-easterly airs, and during the whole afternoon a solar halo was visible. On the morning of Sunday, July 3rd, the air was very warm after heavy dew, and the sun's rays were very hot. It was, therefore, expected that thunder might probably occur during the day, as the warmth was oppressive.

This expectation was strengthened later by witnessing the behaviour of the hazy cumulus clouds which had formed on the evaporation of the dew, as these during the forenoon gave unmistakable signs of collapse and formed long "thunder bars" on the north-western horizon.[1] In the afternoon a sea-breeze sprung up, and a perfectly cloudless sky prevailed with brilliant sunshine.

At 5 p.m. on the north-western horizon a very slow moving cloud bank was discerned and distant thunder was also heard in that direction. By 5.15 the front edge of the bank had crossed the sun, and now it was first noticed that a current of air from the South-south-east was apparently wedging itself underneath the approaching storm-cloud, as a thin layer of stratus had already formed in the north and north-north-west. A few drops of rain fell at 6 p.m., while continuous rumblings of thunder were heard in the west; lightning was also first seen in the west-north-west.

At 6.25 p.m. a brilliant flash of lightning, of inverted tree-like form, was observed in the west, followed at 12 seconds' interval by thunder. Shortly after this there commenced one of the most magnificent displays of lightning ever witnessed in the district. At 6.35 the wind had backed from East to North-east, and was freshening considerably. At 6.42 the thunder-cloud, heavy overhead and in the west, was a most interesting sight, long lines of cloud in wavy and contorted shapes being visible, with tongued projections from which the lightning darted in a quick succession of very bright flashes. All the upper part of the cloud appeared at times ablaze with light, as the electricity played on its surface, and some very pretty fan-shaped flashes, with their converging ends uppermost, were frequently seen. Sometimes a succession of threads appeared to descend from cloud to earth and was provincially described as "chain lightning." About this time the overhead cloud caused intense darkness. At 6.50 the wind was full North and blowing a moderate gale; two minutes later a peculiar long wreath of cloud, like smoke from a chimney, very low and in rapid motion, approached from the north-west, and the wind for a few seconds blew briskly from the West-south-west. At 7.0 the gale from the North-west increased in force, and large drops of rain began to descend rapidly. Ten minutes later the heavy drops of rain fell thick and fast, and the flashes of lightning were suffused pink, giving an intense glow to the northern horizon. At 7.20 the centre of the storm-cloud was directly overhead, and very heavy rain was being driven in immense sheets, every thunderclap seeming to produce water waves in the air. At 7.25 the sky was uniformly covered with *nimbus* and very heavy rain was falling. By 7.35 the heavy rain had passed, and the sun was shining through broken cloud, the wind having in the meantime gone to North-east. It shortly after shifted to West, from which quarter it blew during the remainder of the evening.

The rain that fell at the station during the half-hour's storm measured

[1] See *Nature*, Vol. XXXVIII. p. 221, on a "Prognostic of Thunder," by Mr. B. Woodd Smith.

0·40 in., and a rain gauge a mile further north, and 125 feet higher, recorded 0·56 in.

The full force of the storm was felt in the Wold valleys which lie to the north and north-west of Driffield, where great quantities of soil and gravel were removed from the hillsides (where the tillage for the turnip crops had left the land loose and easily transportable by the flood of water, consequent on the heavy rain), to the lower parts, overturning in its course quickwood hedges and doing a large amount of damage. Many houses in the lower parts of Driffield were flooded and a bridge was so much damaged that it had to be entirely rebuilt.

In a basin of valleys about a mile wide and six miles north of Driffield, to the west of the village of Langtoft, the lower current of cloud, previously mentioned, appears to have accumulated, while the upper north-westerly cloud-bank overflowed and effectually imprisoned it in the valleys.

On the north side of the basin-like range of valleys, whose only outlet was at the south-east corner, an abrupt valley runs to the north with steep declivities.

At a place named "Round Hill," on Saturday, June 9th, 1888, about noon, a waterspout had torn its way into a slight hollow or combe on the hillside taking a north-easterly course, and formed three large holes in the chalky rubble scattering the stones all around, producing a flood which inundated the village lower down the valley.[1] These holes, which are roughly circular and connected by a deep trench, are well shown in Figs. 1 and 2,[2] and measured from one end to the other about 70 yards, and were from 8 to 9 feet deep in their deepest portions. Several tons of soil, boulders, and gravel were thrown out and carried down the valley by the flood, and the village streets were covered with a mixture of these substances. The damage done by that flood of 1888 was, however, insignificant when compared with the one now under discussion. Not more than 20 yards from the site of the former cloudburst, or waterspout, and a little further to the south, three gutters or trenches have been scooped out of the solid rock, nearly parallel to each other and at right angles to the valley bottom; the direction taken being slightly more easterly than that on the former occasion. From the appearance of the trenches it is highly probable that there were three waterspouts moving abreast simultaneously.

Two of the trenches, or ravines, are 68 yards in length and of great size and depth, and as the hillside here somewhat differs from the adjoining portion, where it consists of loose chalk mixed with soil and is composed of strata of solid rock slightly inclined to the vertical, beneath a thin layer of earth, the force exerted in removing the ponderous mass of material, about 180 yards in circumference, must have been very great indeed. The smaller trench,

[1] See *Symons's Monthly Meteorological Magazine*, July 1888.

[2] **The blocks illustrating this paper have, by permission of the publisher, been taken from Mr. J. D. Hood's book, *Waterspouts on the Yorkshire Wolds*.—Ed.**

J.H.

15 yards to the left and much shallower, is rather over 50 yards long, but this is discontinued before the summit of the hill is reached, as the gyratory power of the tornado had evidently become weaker and the spout was presumably drawn up again into the cloud. Traces of the irregular motion

FIG. 1.—The Round Hill.

FIG. 2.—Portion of the Hill struck by the Waterspout, showing the dislodged Chalk.

attributed to waterspouts are perceptible in the trenches, cavities having been scooped out as the spouts ascended the hillside and crossed the ridge; these are most noticeable in the smaller channel to the left, where the zig-zag motion of the spout has scored out a series of little pits at almost regular intervals

apart, throwing out a quantity of small stones as it moved forward. There are no definite signs of any whirling motion to be seen in the trenches, but midway of the two larger ones a perceptible widening of the ravine has taken place and the dimensions of that on the right are 12½ feet in diameter and 8½ feet in depth. There seem to have been no stones thrown out sideways from the larger trenches, or if so, they have been carried down by the flood of water to the base of the hill. In the 1888 waterspout, many small stones appear to have been scattered on both sides of the trench. As the energy of the waterspouts was lessened in expelling the vast quantity of rock, the spouts appear to have narrowed considerably, as well as converged towards each other, as they moved further up the hill, for while at the base the distance apart of the two larger trenches is 25 feet, and the small one 45 feet from the one midway, measured at the upper end of the smaller one, the two on the right are only 17 feet apart, and the small one 37 feet distant.

The probable causes that bring about the formation of these waterspouts or cloudbursts of this particular spot may lie in the peculiar character and configuration of the surrounding valleys, which all converge to a point south of this place, and have only one outlet to the east, while the north-easterly side upon which the waterspouts impinge is strongly fortified by steep declivities which appear to impede the storms in their path. Here, possibly, the overcharged undercurrent of warm air, supplemented by the warm air of the valley (for the afternoon sun had been bright and hot), was suddenly broken into and disturbed by the cool rain and air descending from above, and a series of whirls were formed, which, after developing into waterspouts and conforming to the laws of tornado motion, moved away in a north-easterly track, and hence came in contact with the steep hillside, where, finding their paths impeded, they tore huge holes in the hillside.

This theory gives plausible ground for the assumption that previous floods have been brought about in the same manner. One of these, and the greatest presumably of four, is recorded in stone on the gable end of the cottage shown in Fig. 3, and is as follows:—

Another flood within the recollection of the present inhabitants, of which unfortunately there is no printed record, took place in the third week in June 1857 (?), when many acres of turnips were washed away.

Traces on the hillside and in the valley of both these floods are probably now not discoverable, although it is possible that the site of the 1888 waterspout may be that also of some previous one, as there are some slight traces of an earlier erosion, The third flood mentioned in the earlier part of this paper occurred on June 9th, 1888: and now we have the extraordinary storm of July 3rd, 1892, to add to the list. All these flood-storms must have origi-

nated within a mile or so from the village of Langtoft, which, as may be seen from the map (Plate I.), is perfectly surrounded by hills, excepting on the south-eastern side, where lies the only single outlet valley.

Other floods may be expected to follow in the course of time, when similar atmospheric conditions again manifest themselves for the production of these waterspouts.

With regard to the enormous amount of damage done to the village and neighbourhood little need be said, as this has been fully dealt with in the *Driffield Times* of July 9th, 1892. Suffice it to say that a great wave of muddy water, variously estimated at from 7 to 9 feet in height, swept into the village, after combining with other streams from the surrounding valleys, carrying all before it, without a minute's warning burst open the doors and dashed into the cottages, lifted the furniture from the floors and floated it away; frightened the cottagers, drowned their pigs and fowls, filled the lower rooms of their houses with a sediment of mud, and then made its way down to the central parts of the village. Here, after crossing the village pond and wrecking a workshop in its path, as well as flooding a farmstead, scattering the straw ricks far and wide, it burst with fury on a block of cottages and almost totally demolished them. These are well shown in Figs. 3 and 4.

FIG. 3.—Cottage with inscribed Stone of height of Flood in 1657.

It then turned south and flowed down the valley, strewing all its path with *débris*, and finally made its exit by the only outlet available at the lower end of the village almost as quickly as it had come, leaving behind it a large tract of country covered with a deposit of mud and wreckage several inches deep.

The destruction to property and crops was very great, and a relief fund was at once organised, which in some measure alleviated the distress of the

inhabitants, over £1,300 being subscribed, but the memory of the disaster will doubtless long survive in the district, to be handed down to succeeding generations as the Great Flood of 1892.

FIG. 4.—Some of the Wrecked Houses.

APPENDIX.

NOTES AND EXTRACTS ON WATERSPOUTS AND CLOUDBURSTS.

Collected by the Author.

In the light of recent experience of the Langtoft Waterspouts, it may be interesting to compare observations made on previous similar occurrences, together with the opinion and particulars as to the cause of such outbursts by several eminent authorities.

The following extract is taken from Scott's *Elementary Meteorology*, p. 382:—

"If the track [of a whirlwind] crosses a sheet of water or even a river, a waterspout is formed during the transit, as at Königswinter, on the Rhine, June 10, 1858."

The Hon. Ralph Abercromby, in his book on *Weather*, p. 267, remarks:—

"A tornado is simply a whirlwind of exceptional violence; if it were to encounter a lake or the sea, it would be called a waterspout. Its most characteristic feature is a funnel, or spout, which is the visible manifestation of a cylinder of air that is revolving rapidly round a nearly vertical axis. This spout is propagated throughout the northern temperate zone in a north-easterly

direction at a rate of about thirty miles an hour, and tears everything to pieces along its narrow path."

Mr. G. J. Symons, in speaking of the Batcombe Waterspout in the *Meteorological Magazine*, of July 1889, p. 85, says:—

"It is much to be regretted that no record seems to have been preserved as to whether the water was fresh or salt. Our impression is that it was probably sea water lifted from the English Channel by a whirlwind, and dropped upon the top of High Stoy."

Here, then, the waterspout is supposed to be simply a whirlwind that has crossed some water and sucked up a quantity, letting it fall again in its course as it traversed the land until the supply is exhausted. Ferrel shows, however, that this is not so, the water being part of the formation of the cloud-whirl, its central rapid revolving core having the power of condensing the vapoury particles to water, which under such conditions falls in streams, or is poured down in the form of a spout. Thus, on page 401 of the *Popular Treatise on the Winds*, speaking of waterspouts, he says:—

"As soon as the ascending and expanding air in a tornado cools down to the dew point corresponding to the diminshed vapour tension as it gradually comes under less pressure, condensation and cloud formation take place. Wherever the ascending air arrives at the depressed isobaric surface, it has cooled down to the same temperature; and condensation and cloud formation take place as soon as the air ascends above or enters within that surface up as high as aqueous vapour is carried by the ascending current. But without and below this surface there is no condensation and cloud formation, and the air remains unclouded. The clouded portion of the air therefore assumes the form of a tapering trunk, and we have the phenomenon called a *waterspout*. A waterspout, therefore, is simply *the cloud brought down to the earth's surface by the rapid gyratory motion of the tornado.*"

After treating of the variety of forms which the waterspouts assume—

"From that of a cloud brought down over a large area of the earth's surface in a tornado, where the air is nearly saturated with vapour and the general base of the cloud very low, to that which occurs when the air is very dry and when the tornadic action is barely able to bring the cloud down from a great height into a slender spout of small dimensions"—

Ferrel goes on to say:—

"There are often two or more spouts in close proximity. Sometimes several small spouts protrude from the lower base of the cloud in the same vicinity, some to a greater and some to a less distance down, sometimes not differing much in size; at others there is a larger and principal spout accompanied by one or more smaller ones."

In the Langtoft case there were two principal spouts, and one on the left side. On p. 412 Ferrel proceeds:—

"As the tornado originates in air in the unstable state, it often happens that there is about an equal tendency in the air of the lower stratum to burst up through those above at several places in the same vicinity at the same time. Each of these gives rise to a separate and independent gyration in the atmosphere, and a small funnel where they are of sufficient violence; but generally, as they increase in dimensions and violence, they interfere with one another and finally become united into one."

In the Langtoft instance, after expending considerable energy midway on the hillside, both the principal spouts appear to have suddenly contracted in

width, and as they moved forward their tracks slightly converged, still further narrowing before crossing the ridge. On page 413:—

"It was formerly supposed that the spout consisted of water drawn up into the clouds from the sea, and that the real waterspout was found on seas and lakes only, and hence the name. It is true that a considerable amount of water may be drawn up from the sea, but this is merely an incidental and secondary matter and has nothing to do with the formation of the spout. The amount of water drawn up is so small generally in comparison with the amount of rainfall, that the latter is never observed to be sensibly affected by it at sea, but always appears to consist of fresh water."

Passing on to the consideration of Cloudbursts, on p. 429 it is stated:—

"Considering the strong ascending currents in tornadoes, and their great supporting power, as deduced from theory and exemplified in numerous cases of observation, it is not to be wondered at if great accumulations of rain and hail are sustained for a while by these currents at a considerable altitude in the vortex of the tornado, and then, on account of a sudden weakening or breaking up of the tornado for some reason, a great amount of rain and hail should sometimes fall to the earth in a short time. Such abundant and sudden precipitations are called *cloudbursts*. If the velocity of the ascending current in the interior is not so great that the rain is all carried up where the current is outward from the vortex, or where this outward current and the centrifugal force of the gyrations together are able to drive it out where it can fall through the weaker ascending current, and yet is great enough to prevent its falling back, then in the whole of the lower part of the cloud in the central part of the tornado, even up to an altitude of three miles or more, there may be a great accumulation of rain, prevented by the ascending current from falling, and also by the centripetal in-drawing current below a given level from being carried out and dispersed. Of course a considerable part of the energy of the tornado is required to support the mass, so that, as this increases, the strength of the ascending current is weakened, until finally the whole mass suddenly falls. Or the whole system may become weak and break up from some other cause, when the same result follows. This is especially liable to occur in mountainous regions; for if we suppose that a tornado thus heavily charged with rain is moving toward the side of a mountain, its coming in contact with it would interfere very much with the gyrations and energy of the tornado, and tend to break up the whole system almost at once, and let the whole accumulation of water drop suddenly down. Hence, cloudbursts most frequently occur on mountain sides.

"The water in cloud bursts does not generally fall as rain, but is *poured down*. Long before the ascending current is so reduced as to allow it to fall in drops, the water seems to collect together at certain places and to force its way downward, through the ascending current, in a stream. This it would naturally do, since we cannot suppose that it is ever evenly distributed over any given place, or that the velocity of the ascending current is exactly the same at all points in the same vicinity. A considerable body of water having been collected at certain points, it is there able to force its way down, and it draws into its train much more from all sides on its way, so that continuous streams of water are formed and kept up for several minutes, during which an immense amount of water falls on a number of small spots, while not even raindrops fall between on account of the strength of the ascending current, through which water can only be poured down. Having collected in large masses and once made an opening for itself at one or more places, the velocity of the streams is gradually accelerated, since the ascending current then is not able to support them, so that on reaching the earth the velocity may become immensely great, and the streams strike with great force. Each one of these descending streams may make a great hole or basin in the ground; and on a steep mountain side, if the stream continues for a short time only, it may give rise to a mountain slide, or at least to a great ravine, and carry rocks and trees with it down the mountain side."

On p. 430:—

"Sometimes the current descending through the atmosphere seemed to strike the earth with so great a force that it made a great hole or basin and then re-

bounded so as not to strike the earth again on the mountain side for a considerable distance below. Several of these holes were often found close together in the same vicinity, indicating that the water was poured down at the same time through several openings made in the current of ascending air by the concentration of large bodies of water at those places."

This assumes that the cloudburst came down the hill from above, whereas in the Langtoft one it is quite as reasonable (and more probable) to suppose that the downward stream of water moved towards the hillside and struck the hill at its base, working up its ravine from below. That the Langtoft cuttings were caused by a waterspout is determined by the smaller cutting or trench, where the zig-zag motion of the spout had scored a series of little pits at almost regular intervals apart, throwing out a quantity of small stones as it moved forward.

Ferrel, on p. 406 :—

" As the energy of the tornado and the velocity of the gyrations increase, it [the spout] may be brought either wholly or only part of the way down to the earth's surface. Finally as the energy of the tornado becomes exhausted, and the velocity of the gyration diminishes, it is drawn up again apparently into the cloud, its last appearance being again that of the funnel shaped cloud."

P. 407 :—

" The action of a tornado is somewhat intermittent, now stronger and again weaker. This intermittent action in tornadoes is often indicated by the dropping down and rising up of the spout where the gyratory violence of the tornado is barely sufficient to develop a spout, and is an explanation of this phenomenon; for in that case a very little increase or decrease in the rapidity of the gyrations brings the spout in part or wholly to the earth's surface from the funnel shape, or lets it up again.

This is beautifully illustrated in the Langtoft waterspouts, where as the energy of the spouts became exhausted by expelling the rock at the lower part of their paths at the foot of the hill, they considerably narrowed as they moved up the hillside, until before the ridge of the hill was crossed they had raised themselves from the ground, their energy being expended in ascending the hillside.

On p. 418 :—

" If it were necessary to change the name, which, as in many other things, was given before the thing was understood, it would be more appropriate to call them *vapour-spouts*, since they are evidently composed of condensed vapour, and no amount of rotary motion in dry air would produce such a phenomenon."

Turning now to Prof. James Thomson's address on Waterspouts at the Montreal meeting of the British Association in September 1884, we find it there stated as follows :—

" The supposed accumulation of air rarefied by heat or otherwise, for producing the abatement of pressure, may be in the form of a lower warm lamina, which somehow may have been overflowed or covered by colder air above, through which or into which it will tend to ascend.

" The influx of air so arriving at the central region cannot remain there continually accumulating; it is not annihilated, and it certainly does not escape downwards. There is no outlet for it except upwards, and as a rising central core it departs from that place.

" This rising central core may, perhaps, in virtue of its whirling motion and centrifugal tendency, afford admission for the cloudy stratum to penetrate down as an inner core within that revolving ascending core, now itself become tubular.

The cloudy stratum may be supposed not originally to have been endowed with the revolutional motion or differential horizontal motion with which the lower stratum of thermally expanded air has been assumed to be originally endowed. The upper stratum of air from which the cloudy spindle core is here taken to protrude down into the tubular funnel is not to be supposed cold enough to tend to sink by mere gravity. Though it were warm enough to allow of its floating freely on the thermally expanded air below, it would still be sucked down into the centre of the revolving ascending core of the whirlwind."

The above entirely agrees with what presumably took place at Langtoft, as two strata of cloud, a lower warm current from the South-south-east and a higher and colder current from the North-west were observed, and apparently the under current was blocked in the valley where the waterspouts occurred, and liberated itself in the form of waterspouts, as no other means of escape was permissible, owing to the formation and configuration of the surrounding hills.

In the account of the thunderstorm and whirlwind at York, March 8th, 1890, in the *Quarterly Journal of the Royal Meteorological Society*, Vol. XVI. p. 177, a remark by Captain Key appears to be appropriately given here in connection with the two currents of cloud seen during the Langtoft tornado. He writes :—

"It appears to me as if two angry thunder-clouds met over the Archbishop's Palace at Bishopsthorpe, one coming from the south, the other from the north-west. Then there was a sort of roar, the hut trembled and all was over in less than a minute."

In the Hon. Ralph Abercromby's *Weather* the following account is given on p. 275 of a tornado in progress :—

"The cloud from which the funnel depended, seen at a distance of eight miles, appeared to be in terrible commotion ; in fact, while the hail was falling, *a sort of tumbling in the clouds was noticed as they came up from the north-west and south-west*, and about where they *appeared to meet was the point from which the funnel was seen to descend.* There was but one funnel at first, which was soon accompanied by several smaller ones, dangling down from the overhanging clouds like whip-lashes, and for some minutes they were appearing and disappearing like fairies at play. Finally one of them seemed to expand and extend downwards more steadily than the others, resulting at length in what appeared to be their complete absorption. This funnel-shaped cloud now moved onward, growing in power and size, whirling rapidly from right to left, rising and descending, and swaying from side to side."

Here, again, we have an analogous case where two opposing cloud currents meet and form a funnel or waterspout. In an article in *Nature*, May 31st, 1888, by Mr. E. Douglas Archibald, the following explanation of the formation of tornadoes or waterspouts is given:—

"A current ascending up the axis, combined with rapid rotation round it; a hyperboloidal funnel of rarefied air tapering downwards, and reaching the earth when the action is powerful, round the sides of which a condensed vapour, or so-called waterspout, should usually prevail, owing to the sudden rarefaction of the air entering the central area through the sides or at the base, with the consequent lowering of the plane of condensation from the cloud-level which it usually occupied. When, therefore, it is said that 'a waterspout is simply the cloud brought down to the earth by the rapid gyratory motion of the tornado' (see Ferrel's *Treatise*), it is not meant that the cloud is actually carried downwards by an aerial current, since by theory the motion is precisely in the opposite direction ; but that the *conditions* of *condensation* are propagated downwards from the cloud-stratum where they first commence. Neglect of this considera-

tion, as well as the physical fact that condensation can only occur under most exceptional circumstances in a *downward* current, has led to many false deductions from apparent circumstances."

In the *Meteorological Magazine* of September 1886, on p. 119, a waterspout is described as having burst on Kilvey Hill, near Swansea. A correspondent, on p. 137, gives the particulars of the locality as follows:—

"The Swansea Valley is similar to those usually found in Wales, and runs north and south [similar to the Langtoft Valley], Kilvey Hill being on the south-east extremity."

The description of the storm is given thus:—

"At 3 p.m. the sky was again darkened by heavy clouds, most fantastically shaped, and for an hour a thunderstorm, accompanied by a perfect deluge of rain, prevailed. At both Swansea and the Mumbles vast streams of rain rushed down the hills with such velocity as to make deep watercourses in the centre of the roads. But at Foxhole, a suburb of Swansea, what was elsewhere a torrent took the form rather of an avalanche than that of anything else. This portion of the town is built at the base of Kilvey Hill, the highest eminence near Swansea, rising as it does 650 feet above the level of the sea. The side is almost as steep as a wall, but towards the base it slants somewhat, and here are rows of houses.

"During the progress of the storm a waterspout was observed to travel from the bay in the direction of Kilvey Hill. (Query—Was this really a waterspout or a warm current of low cloud flowing in from the south?) It burst, and immediately ensued a scene the like of which has probably never been seen in England. Great torrents rushed down the mountain side, cutting deep channels through which to pass, and carrying with it every obstacle, even to huge boulders weighing several hundredweight. These torrents or avalanches—for there were many of them—rushed down at a great rate to the first row of houses, and it is a curious fact that though the walls of but few of these were demolished, the torrent never stopped, but, bursting in back doors and windows, carried all the contents of the dwellings with it. It is estimated that altogether about 8,000 tons of earth and rock were carried down the precipitous sides of the mountain by this awful torrent. The extremely local character of the fall is proved by the fact that the three nearest rain gauges all collected less than two inches."

It would be most interesting to learn, as the above is an exactly analogous case to that of Langtoft, whether the waterspout *really was seen* to come from the bay, or it was simply the writer's imagination that supplied it, and whether it did not rather form in the valley which "ran north and south and had the Kilvey Hill on its south-east extremity" by the opposition of two currents, the one from the south or some southerly point, and the other from a north-west direction.

Note added November 4th, 1892.

Since the foregoing was written a letter has appeared in a little illustrated work by Mr. Hood, on the *Waterspouts on the Yorkshire Wolds* (a copy of which is in the Society's Library), in which Mr. Digby Cayley, of Malton, describes what he saw of the storm from his position three miles west of Round Hill.

The following is a copy of the letter referred to:—

"I was at Cowlam on Sunday, July 3rd, the day of the fall of the great waterspout. I left there about 6 p.m. thinking I might escape the storm, which had been gathering up from the west all the afternoon. I had got

about one mile on my road to Lutton when I observed approaching me from the west a particularly dense black cloud with four long black columns depending from it. The longest and blackest one appeared to come down to within some 150 to 200 feet from the ground.

"The cloud suddenly wheeled to the south-east, and apparently moved on rapidly towards Cowlam, which I had just left.

"Up to that time, although the thunder and lightning were appalling, no rain had fallen on me. Suddenly there came a flash of lightning close over my head, and a terrific peal of thunder almost at the same moment, and the next moment all was black and the water fell in bucketfulls, and the inky darkness completely hid the black cloud I had previously noticed. My gig was full of water, and it came down the road in a broad torrent nearly a foot deep."

In a further communication from Mr. Cayley, he states that he was about three-quarters of a mile from the cloud and its pendulous columns when observed, and that the cloud was decidedly blackest near the longest column and at its northern end.

From this account it would seem probable that the waterspouts were already in process of formation some three miles or more distant from, and in a direct line with the trenches on, the hill upon which they subsequently struck. This somewhat modifies the theory proposed in the preceding pages that the waterspouts had their origin in the valley adjoining the Round Hill. We may, however, infer that the peculiar configuration of the valley was a means of developing the waterspouts to an excessive degree, and that their intensity and violence there became so great that they were unable to move out of the valley without striking the hill with the disastrous results already detailed.

It may be thought worthy of mention that hailstones fell in the front part of the storm as it crossed the village of Langtoft, though they were not observed three miles to the west, nor on the southern edge of the storm.

DISCUSSION.

Mr. Scott said that at the Meeting of the Society on March 20th, 1878, three papers describing appearances of waterspouts were read. One of these communications gave an account of a waterspout experienced in the Ochil Hills, Perthshire, a locality which appeared to somewhat resemble the district around Langtoft. As well as he could remember, the late Mr. Penny, of Nairn, had informed him that the Ochil Hills had been the scene of waterspout discharges on several previous occasions, and this statement coincided with that made by Mr. Lovel concerning former cloudbursts in the neighbourhood of Langtoft. During last autumn, while travelling in the west of Ireland, he (Mr.Scott) had almost witnessed a small waterspout. The weather at the time was squally with hail showers, the wind being in the North-west. While travelling along the coast he saw a "pocky" cloud formation (which Dr. Clouston had stated was always the precursor of severe weather), and kept a sharp look out for waterspouts, but failed to see any. He had since learned, however, that a whirlwind had occurred in the vicinity, and he had written a brief account of the phenomenon for insertion in the *Quarterly Journal* (see p. 58). One curious fact was that two men connected with the "Congested Districts Commission" were engaged surveying with a 66 feet tape when the whirlwind passed over, and the tape was caught by the wind out of the men's hands and thrown into the sea.

Admiral Maclear said that possibly waterspouts at sea and cloudbursts on

land had their origin in similar causes, but there was certainly a difference between the phenomena themselves. Cloudbursts appeared to be associated with, or accompanied by, strong wind, but waterspouts almost invariably occurred in calm weather, or with very light wind. Certainly ninety-nine per cent. of the waterspouts he had seen were unaccompanied by wind. There was usually a very slight movement perceptible in the clouds as they descended towards the sea, and slight turmoil could be noticed when the descending cloud reached the sea's surface. He had endeavoured on various occasions to obtain measurements of waterspouts, and from observations he had made he had calculated that they were generally about 15 feet in diameter. This result had been arrived at by using a sextant, the distance of the object measured being estimated as accurately as possible, and also by imagining a ship at the same distance as the waterspout and computing how much of the vessel would have been hidden by the waterspout. Of course the funnel from the cloud and the smaller cone in the sea were of greater diameter. He was much surprised to notice that Ferrel quoted observations of waterspouts of as much as 1,000 feet in diameter.[1]

Mr. BRODIE said that it was not often possible to trace any connection between phenomena of a purely local character, such as the Langtoft waterspout, and the distribution of pressure shown by synoptic charts, the isobars on which are as a rule drawn for even tenths of an inch. An examination of the charts for the day in question showed, however, that a distinct barometrical depression had been formed over the north-east of England, its centre being shown at 6 p.m. near Doncaster. In the course of the evening the depression travelled north-eastward to the North Sea, and from the changes in wind reported by Mr. Lovel it was evident that the centre of the system passed a little to the eastward of Langtoft.

Mr. TRIPP remarked that it would be interesting to know what effect these cloudbursts would have on the rainfall registered if averaged over their proper districts, but unfortunately such phenomena usually occurred in localities where no rain-gauges were established; and even if there were any available it appeared probable that they would be swept away by the torrent of water. He supposed that the precipitation resulting from cloudbursts could hardly be classed with ordinary rainfall. Mr. Backhouse has shown in his paper[2] some time ago how improbable, judging from mathematical reasoning, was the occurrence of even such falls of rain as one inch in 24 hours, and from Mr. Tripp's knowledge, so far as it goes, of localities where these cloudbursts have occurred, there is generally only one record of such an event within human memory in any one spot. In the district mentioned in the paper there are apparently records of more than one, but this appears to him exceptional.

Captain WILSON-BARKER said that he could corroborate Admiral Maclear's remarks as to the absence of wind when waterspouts occurred. In the case of those which he had been fortunate enough to witness there was very little movement either above or below, there being very slight agitation of the water and practically no cloud movement whatever. On one occasion a waterspout passed quite close to the ship, and he put his hand out to ascertain whether there was any air movement in the immediate vicinity of the phenomenon, but failed to detect any; in fact, had he not seen the agitation of the water he should not have been aware that any disturbance was in progress. He had obtained two photographs of waterspouts from slow moving clouds. It was worthy of note that waterspouts were generally only produced in what were styled the transition regions, or the districts situated on the borders of areas over which the great wind systems of the world prevailed. They were practically unknown in the Trade Wind regions.

Mr. SYMONS said that he did not wish to question the strong arguments advanced by the late Prof. Ferrel to prove that waterspouts are vapour formations, but at the same he could not understand, supposing Ferrel's theory to be correct, how it was possible to account for the showers of fish and similar extraordinary occurrences which were, undoubtedly, occasionally experienced. He himself knew of an instance in which the whole of the water forming a pond, together with the fish, &c. contained in it, were sucked up by a passing whirlwind; and it could only be supposed that eventually the water and fishes were

1 *A Popular Treatise on the Winds*, p. 408.
2 *Quarterly Journal.* Vol. XVII, p. 87.

deposited on the earth again in another locality. With reference to the flood of June 1857, mentioned by Mr. Lovel, he (Mr. Symons) knew that a great cloud-burst fell over Scarborough and the surrounding villages about that date, when an enormous amount of destruction resulted. There happened to be a rain gauge in the area affected, and although of sufficient capacity to contain 9½ inches of water, it overflowed. He did not think that the locality of the cloudburst at Swansea, which had been cited by Mr. Lovel, was fairly comparable with that at Langtoft, Swansea being a wide open valley, while that near Langtoft formed a *cul-de-sac* in the hills.

He then read the following extract from an old volume of the *Philosophical Magazine*, giving an account by Dr. D. P. Thomson of a waterspout which burst on Bredon Hill, North Gloucestershire, on May 3rd, 1849:—

"About half-past five in the afternoon of Thursday, the 3rd of May, 1849, during a storm of thunder, lightning, and hail, an enormous body of water was seen to rush down a gully in the Bredon Hill, and direct its course to the village of Kemerton. The stream was broad and impetuous, carrying everything before it. Its extraordinary force and body of water may be judged of from the fact that, on reaching the residence of the Rev. W. H. Bellairs, of Kemerton, it broke down a stone wall which surrounded the garden, burst through the foundation of another, made a way for itself through the dwelling-house, and then carried off a third wall of brick six feet high. The garden soil was washed away, and 'enormous blocks of stone' and *débris* from the hill left in its place. By this time the current was considerably broken, nevertheless it flowed through the house to the depth of nearly three feet, for the space of an hour and forty minutes. The neighbouring railway was so deeply flooded as to delay the express train, by extinguishing the fire of the engine.

"Upon the Saturday morning, as soon as possible after the occurrence of this remarkable phenomenon, Mr. Bellairs rode up to the Bredon Hill to ascertain its cause. For more than a mile the course of the torrent could be easily traced, from twenty to thirty feet in breadth, every wall being broken down, and the whole, or greater part of the soil, removed. On arriving at the north-west shoulder of the hill, the place where the mass of water had fallen was discovered. It was a barley field of about five acres in extent, the greater part of which was beaten down flat and hard, as if an enormous body of water had been suddenly poured out upon it. Beyond this field and on higher ground, there were no signs of the fall of water to any great amount. The part of the hill where this waterspout had emptied itself was thus fully ascertained. In the vicinity heavy rain had descended, for minor tributaries had left marks of union with the main current, but in these there were nothing remarkable.

"As the water rushed down the hill towards Kemerton, it did not spread itself out as under ordinary circumstances it would have done, but flowed in a body, as if kept together by the velocity of the current, the physical features of the place aiding it in this respect, for there the hill is steep, and the course of the water was in a gully. The general depth of the torrent was from six to seven feet, though in one instance marks upon a tree were met with *sixteen* feet above the ground. We must not overlook, however, the bending of the tree under the power of the stream; consequently, though the mark would lead to the belief that the water had risen sixteen feet, it does not follow that it actually did so.

"The rain ceased immediately after the fall of water, and it is said that a strong sulphurous odour was perceived."

Remarks on the measurement of the Maximum Wind Pressure, and Description of a new Instrument for indicating and recording the Maximum.

By W. H. DINES, B.A., F.R.Met.Soc.

[Received September 22nd.—Read November 16th, 1892.]

Having for a period of some months thoroughly tested the instrument now to be described, and having found it useful and convenient, it appears to me desirable that I should lay an account of it before the Fellows of the Royal Meteorological Society.

In the report on "Anemometer Comparisons" read before the Society in April last,[1] the Tube Anemometer used in those comparisons was described, and it seems unnecessary to repeat the account then given in so far as the exposed part, or head, is concerned. The indicating arrangement is, I believe, entirely novel, and may be used in connection with the head described in that report; but before explaining it in detail, it will be as well to make a few remarks on the subject of wind measurement by the Tube Anemometer.

It seems probable that instruments of this class have fallen into disrepute for two reasons: firstly, because with the ordinary U shaped tube for the indicator, they are incapable of showing the existence of any breeze under force 3 or 4 of the Beaufort scale; and secondly, because of their great unsteadiness.

The tube anemometer is essentially a pressure instrument, and since the mean pressure at an inland station in England can hardly exceed ¼ lb. per square foot, but the actual pressure may at times possibly amount to 30 lbs. per square foot—that is 120 times the mean—it is not surprising that the indications of pressure gauges should often be too small to be perceptible. If the ordinary variations of the temperature did not exceed 1°, yet our thermometers had to include a possible range of 120°, it is obvious that a correct record of the small daily variations of temperature would be very hard to obtain, but this is precisely what occurs in the measurement of wind pressure. To show that the case is not exaggerated, the *Greenwich Observations* may be quoted. During 1889 fifty-one days occurred on which the maximum pressure is given as zero, although on some of these days the horizontal motion of the air given by the Robinson cups exceeded 170 miles.

A fault of this kind cannot be justly charged against the instrument itself, but an observer is naturally prejudiced against an anemometer which, when he looks at it, nine times out of ten shows no sign of any wind.

The second objection, namely the unsteadiness when there is much wind, appears to me to show the perfection of the tube anemometer, and not to be

[1] *Quarterly Journal*, Vol XVIII. p. 165.

a defect, for the unsteadiness is due to the wind, the variations of which are accurately followed. If, however, it be a defect, it is one which is very easily cured.

For the reasons given above it appeared to me desirable so to arrange the scale that the indications might refer to the velocity rather than to the pressure, and since the average velocity of the wind is about one-tenth of the maximum for which allowance must be made, it is possible to have a scale to include all possible winds and yet to show accurately the velocity of the lightest perceptible breeze.

Under ordinary conditions of barometric pressure and temperature the head of the tube anemometer gives the following differences of pressure:—

At 10 miles per hour the difference of pressure = ·0781 in. of water
„ 20 „ „ „ „ = ·2924 in. „
„ 30 „ „ „ „ = ·6579 in. „

and so on, the pressure varying as the square of the velocity.

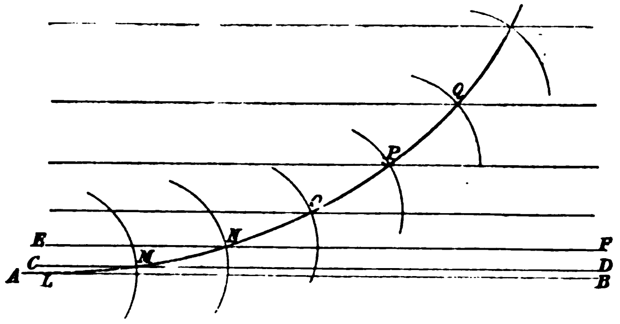

Fig. 1.

To make the indicating arrangement a piece of glass tube of about $\frac{1}{8}$ in. bore is bent to the form of a curve obtained in the following manner:—

A straight line AB is drawn.

Parallel to AB at a distance of ·0781 inch above AB, a second line, CD, is drawn.

Similarly at a distance of ·2924 inch above AB, a third line, EF, is drawn. The fourth line is ·6579 inch above AB, the fifth 1·1696 inch, and so on, the distances being equal to the pressures corresponding to 10, 20, 30, etc., miles per hour.

The curve, which is really a cycloid, is obtained by finding points L, M, N, O, in the lines AB, CD, EF, etc., equally distant from each other, in the manner shown in Fig. 1, and then drawing a curve through L, M, N, O, etc.

Fig. 2 shows the complete arrangement. It must be placed so that the glass tube at the point L may be horizontal, and then have just as much coloured water placed in the bulb as is necessary to bring the end of the column of liquid in the tube to L. The two ends X and Y are then connected with the head of the anemometer by lead tubing; $\frac{1}{8}$ in. bore being sufficiently large.

The tube at the point L being horizontal, the slightest possible change of pressure is capable of moving the end of the column of liquid, and it is also evident from the mode of forming the curve, that equal divisions on the scale correspond to equal increments of velocity. On reference to Fig. 1 it will be seen that the equal distances LM, MN, NO, etc., must exceed a certain

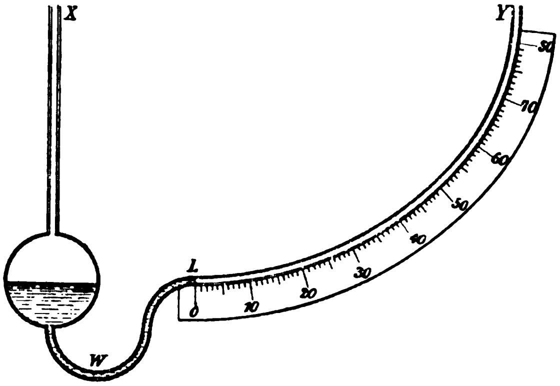

FIG. 2.

minimum length, which depends on the highest velocity it is desired to include in the scale. The distances between the lines showing the pressures for 10, 20, 30, etc., miles per hour, steadily increase, and consequently the part is soon reached where the point of the compass will not reach the next line. After this the scale divisions are not equal. By starting with LM of sufficient length, it is possible to make this point as high as we please, but then the instrument becomes unnecessarily large. Perhaps the most convenient plan is to make equal velocity divisions up to 60 or 70 miles per hour, and then carry the tube up vertically. This sacrifices the symmetry of the scale, but on the whole makes the arrangement more compact.

It is assumed in the above that the level of the liquid in the bulb remains constant; such is not absolutely the case, but the trifling modification of the curve to which the glass must be bent is easily obtained.

An arrangement like the one described above has been in use for some nine months, and I believe that it gives correct indications of the velocity of the wind down to as low a speed as 2 miles per hour.

If it be considered desirable to have a record of the maximum force, a slight alteration is necessary. The bulb which forms the reservoir for the liquid is replaced by a piece of nearly horizontal glass tube. (Fig. 3.)

The application of any pressure at A (Fig. 3) causes the liquid to rise in the curved part of the tube, and at the same time the end of the column near A moves to the right. It is obvious that this end of the column may be used to show the velocity just as well as the other, and if a small index made of fine iron wire be placed in the tube it will be carried to the right by the surface tension of the liquid, but will not return, acting in precisely the same way as the index of the spirit minimum thermometer. It may be brought back and set by a small magnet.

It is convenient to make the horizontal part of the glass tube of larger bore than the curved part, otherwise the scale will be longer than is required.

The measurement of the absolute maximum wind pressure which occurs is very difficult to obtain accurately; and it is quite certain that the maximum recorded will depend upon the particular instrument used, whether it be an ordinary pressure plate, or one of the kind described above. The action of a force depends not only on its magnitude, but also on the time during which it acts, and as the extreme force of a gust lasts for only a very short, but unknown period, it does not seem possible to get rid entirely of the element of time.

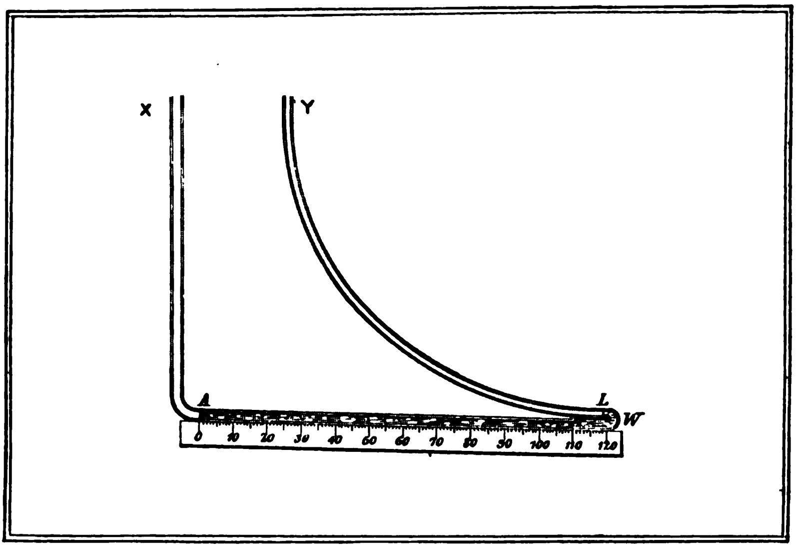

FIG. 3.

If a pressure plate move so easily that the frictional resistance may be neglected in comparison with the force of the wind acting upon it, it can be proved by a strict mathematical demonstration that under certain circumstances[1] which are not very improbable, the maximum pressure recorded

[1] Suppose that a force W applied perpendicularly to the face of a pressure plate drives it back a distance x, then with an ordinary spring, W will vary as x, $W = kx$ suppose, where k is a constant quantity.

Suppose the plate to be in a position corresponding to P lbs. wind pressure, and that the pressure then suddenly rises to P' lbs. and remains at that value.

Neglecting friction, the plate will oscillate about a mean position corresponding to P', and since the resultant force on it due to the wind and spring combined will be proportional to its distance from its mean position, the motion will be harmonic.

The amplitude is $2\,\dfrac{P' - P}{k}$, and hence the maximum force recorded will be $2P' - P$.

If the plate be at its zero position when the gust strikes it, $P = O$, and the recorded maximum pressure, $2P'$, becomes double the actual value.

If we take friction into account, this value is only lessened by twice the frictional resistance, and this should not exceed 1 lb.

will be double the actual pressure which has occurred. This is due to the momentum of the plate, which may carry it far beyond its proper position.

The instrument here described is so far damped by the sluggishness of the liquid in the tube, that it will hardly oscillate at all, and hence it cannot possibly register a pressure beyond the proper amount; but on the other hand, if the extreme pressure should not last for about a second, its full value may not be recorded.

The unsteadiness which is sometimes charged against the tube anemometer is easily prevented by contracting the tube at the point W (Figs. 2 and 3) to a capillary bore. This will quite mask all the wind variations of short period, and a gauge so constructed will give a very good idea of the strength of the wind which has prevailed for some preceding time. The contraction may be carried to any extent that is desired; thus it may be so slight that gusts of a few seconds duration will be the only ones eliminated; or the tube may be contracted to so fine a bore that all variations of strength which do not last for thirty minutes or an hour may be smoothed down. Since glass tube is cheap and easily bent, it is a good plan to use two tubes on the same frame, one open and one contracted. In the open tube the size of the index must be carefully adjusted, so that no motion of the liquid that can be caused by the wind may be able to wash it backwards and forwards. For the other tube a convenient amount of damping is obtained by contracting the tube to such an extent that when the liquid is artificially raised to the 100 mile per hour graduation, it may take five minutes to fall to the 50 mile graduation. It is desirable for the purpose of comparison that all instruments should be exactly similar in this respect. Both tubes can be worked from the same head, and the difference between the maxima given by the two affords a good idea of the character of the wind; a gusty wind giving a considerable, and a steady wind a small difference.

Possibly water is not the best liquid to use, since it evaporates, and also it will corrode the index. The latter difficulty may be overcome by using nickel, or by enclosing the iron wire in very fine glass tube, which can be easily done. The evaporation may be prevented by dissolving some kind of salt in the water—nitrate of copper seems to answer very well. However, the salt appears to make the water viscous, and I have not found much loss from evaporation when using water alone. Perhaps common paraffin oil, but coloured, is on the whole the best liquid; it is very sensitive; it does not

The period of the oscillation being equal to $\dfrac{2\pi}{\sqrt{\text{acceleration at unit distance}}}$ can hardly amount to as much as ½ sec. in any ordinary plate, and hence we can assert with absolute certainty that if the wind pressure rises suddenly from P to P' lbs., and remain for ½ sec. at the higher value, the maximum recorded will be nearly $P' - P$ lbs. too high.

The only doubtful point in the above is the supposition as to the sudden change of pressure, but an inspection of the trace from any self-recording pressure plate shows that the wind pressure often rises very suddenly from a low to a high value, and hence it is probable that the maximum pressures are sometimes nearly doubled in this manner.

corrode the index; it does not freeze until cooled to nearly 0°F, nor evaporate nearly so fast as water.

Of course the specific gravity of the liquid must be taken into account in making the scale.

The level adjustment of the instrument is of great importance in the measurement of light winds, but of little consequence for strong winds. The best plan would seem to be to attach the glass tube to a flat piece of wood or metal and then screw it firmly to a brick wall. The level can be tested at any time by disconnecting from the head, and seeing that the end of the column of liquid comes accurately to the zero mark.

One great advantage of this anemometer is that the indicating part may be placed at any distance from the head, so that there is no trouble about climbing an awkward ladder to read and set it. Doubt has been expressed about the pressures being accurately transmitted through the tubes; but, provided there is no leakage, according to the fundamental principle of hydrostatics, the length and size of the tubes cannot affect the mean value recorded by the instrument. For reasons which are fully explained in the report on "Anemometer Comparisons," it is of the utmost importance that the indicating arrangement shall be independent of the air pressure in the room in which it is placed, and this involves the use of a double tube between the room and the head. As previously stated, the tubes may be of any length, but if the distance is great, it is as well to use a larger size than ⅛ in. bore, since a long fine tube acts in precisely the same way as contracting the bore of the glass gauge, that is, it damps the vibrations, without altering the mean position of the liquid column.

In conclusion, it must be stated that the tube anemometer actually records the pressure, and that the velocity graduations on the scale are made solely for the purpose of rendering light winds preceptible. Thus 100 miles per hour shown on the scale means that the pressure upon a circular plate of 1 square foot area is 30 lbs. Under ordinary conditions the values of the velocity given are approximately correct, but if the barometer be exceptionally low, the 30 lbs. pressure will require a somewhat higher velocity than 100 miles per hour to produce it. The correction required is very trifling, for if the barometer were two inches below its mean value, the recorded velocity would be only a little more than 3 per cent. too low.

DISCUSSION.

Mr. Munro said that he was both pleased and surprised at the extreme sensitiveness of Mr. Dines's new instrument. He had had considerable experience with various forms of anemometers, but he liked Mr. Dines's arrangement better than any. He thought Mr. Dines deserved the hearty thanks of meteorologists for producing an instrument which was not only pretty, but had the merit of being thoroughly simple and reliable.

Mr. Inwards suggested that the placing of a little oil on the surface of the water would effectually retard evaporation.

Captain Wilson-Barker said that if the anemometer only worked as satisfactorily as Mr. Dines hoped, there was little doubt that we had now really attained to a thoroughly good instrument. The ordinary forms of anemometer were very

faulty and expensive, but Mr. Dines's arrangement was not difficult of construction, nor was it likely to be costly. After all, for meteorological purposes, it was not of so much importance to ascertain actual values, as to be able to obtain results strictly comparable, and with Mr. Dines's instrument it would be perfectly easy to ensure absolute similarity in construction. He thought Mr. Dines should be congratulated on the production of such an instrument, and also that all were much indebted to him for the great pains he had taken in the matter of wind force.

Prof. LAUGHTON said that in all the work carried out by Mr. Dines it was difficult to know which to admire most—his methods or his results. He had watched the progress of Mr. Dines's anemometrical investigations with very great interest, and would most heartily congratulate both Mr. Dines and the Society on what seemed a satisfactory solution of this much vexed question.

Mr. C. HARDING remarked, in reference to what had been said by Captain Wilson-Barker, that he understood that Mr. Dines's instrument gave absolutely true results. It had long been known that the pressures of 60 and 70 pounds on the square foot, which had been recorded on various occasions, were incorrect, and he was extremely pleased to see Mr. Dines's new and useful arrangement

Mr. CURTIS said that it was one of the merits of Mr. Dines's new form of indicator that, in addition to its simplicity and compactness, it could be easily attached to the self-registering apparatus devised for the tube anemometer, and described by him in a recent paper read before the Society. The two could be worked from the same head, and while the one would give a continuous record of the force, expressed either in pressure or velocity, the other would enable us to note the force at any moment; the combination making the instrument complete. The tube anemometer would be of great service in those cases where it was desired to have the indicator in a place to which the mechanism of any of the ordinary forms of anemometer could not readily be brought.

Mr. SYMONS said that for many years past he had repeatedly drawn attention to the unsatisfactory exposure of anemometers, and was glad to welcome Mr. Dines's instrument as being independent of buildings for purposes of exposure. The head was so simple that it could be mounted on a pole free from all obstructions. He thought that naval meteorologists would rejoice at the prospect of having an anemometer which could be fixed to the mast of a ship, so that there was some prospect of trustworthy anemometrical observations being made at sea. He should like to see the instrument arranged so that a continuous record could be given.

Mr. HIGHAM said that he had made a study of the question of anemometers, and had urged Mr. Dines to proceed with the work of perfecting his form of tube anemometer, as such an instrument was much needed for engineering purposes. He thought it would be possible to combine his method of electrically recording the direction of wind (as shown at the Society's Exhibition of Instruments in March) with Mr. Dines's instrument, using the same vane, so that the direction of the wind as well as its pressure could be simultaneously ascertained.

The CHAIRMAN (Mr. Brewin) inquired whether Mr. Dines had yet had time to compare the results of the working of his new form of anemometer with other apparatus for registering wind force.

Mr. DINES, in reply, said that oil might be put on the surface of the water in the bulb, but that it would not do to put it in the tube, because the capillary attraction of water in a greasy tube was so uncertain. He preferred oil to water chiefly because with oil the perfect cleanliness of the tube was not of so much importance. When making the anemometrical comparisons, he had at first intended using Hagemann's instrument, but he found that owing to the fact that the given velocities depended on the air pressure of the room in which the recording apparatus was placed, it could not be relied upon to give accurate results. With regard to the accuracy of this instrument, he had obtained the constants by direct trial upon the whirling machine at velocities reaching up to 70 miles per hour, and also he had found that when exposed to the natural wind side by side with a pressure plate, the means recorded by the two had differed by less than 1¼ per cent. He agreed with every word that Mr. Symons had said about the evils of exposing anemometers close to chimney stacks and other obstacles to the free motion of the air. In reply to Mr. Curtis he said that the instrument could

be used in connection with the self-recording apparatus described in the paper on "Anemometer Comparisons," and worked from the same head. If used on board ship, the inclination of the head to the vertical, as the vessel rolled, would not matter, and the recording apparatus might be placed on gymbals, but the motion of the mast head, caused by the rolling, would produce an artificial wind which it would be very hard to eliminate.

MOVING ANTICYCLONES IN THE SOUTHERN HEMISPHERE.

By H. C. RUSSELL, B.A., F.R.S., F.R.Met.Soc.,
Sydney Observatory, New South Wales.

(Plates II. and III.)

[Received November 1st.—Read December 21st, 1892.]

Since Western Australia established in 1887 a number of new Meteorological Stations, it has been possible to make our Weather Charts more complete and to trace the progress of meteorological conditions more minutely: and the opportunity has not been lost. Some of the results are of purely local value as aids in forecasting. Others seem to have more general significance, and will, I think, be of interest to the Fellows of the Society and to meteorologists generally, because they have an important bearing upon accepted theories in explanation of "weather" in latitude 20° to 50° South. So much so that I think it will be necessary to modify those theories. There can be no doubt that the great extent of ocean, as compared with the land, in the latitudes named affords to atmospheric circulation a field in which it may approach what it would be if the earth were completely covered by water and the atmosphere therefore free from the disturbing influences of unequal heating, surface land friction, and mountains.

The leading fact that our[1] investigations have brought to light is that Australian weather south of 20° South latitude is the product of a series of rapidly moving anticyclones, which follow one another with remarkable regularity and are the great controlling force in determining local weather.

The fixed anticyclone over the Indian Ocean in these latitudes, which is found in books of reference, must give place to a moving series. It is not

[1] In the investigations which lead up to the results detailed in this paper I have been very ably assisted by Mr. H. A. Hunt, who prepares the daily Weather Chart, and who has carried out many investigations to the successful discovery of weather laws here.

difficult, now that the true weather conditions are known, to trace the development of the idea of a fixed anticyclone over this part of the ocean. The moving anticyclones are about five times as large in area as the low pressure V between them, and they are also moving to the east at the rate of about 400 miles per day. Now vessels crossing these at random would necessarily find five times as much high pressure as low pressure: and if travelling with the anticyclone would keep in it for many days, perhaps all the way from the Cape to Sydney, as the *Hananah* did. When all these barometer readings came to be plotted on the chart the result was a fixed anticyclone, which we now know has no existence in fact. It is not so easy to trace the history of the "overland" fixed anticyclone of more modern writers, but it is equally imaginary. The high pressures regularly move on over land as well as over ocean.

It will perhaps be more convenient if I state here, in as few words as possible, some of the results obtained, and bring forward subsequently in more detail the data upon which they are based. These results may be briefly stated as follows:—

1. Instead of fixed anticyclones we have a series of moving ones.

2. The average number of anticyclones passing over Australia in a year is 42, and so far as the observations go the number varies but little. See Table I. (p. 26).

3. Anticyclones are more numerous in summer than in winter. See Table I., and diagrams 9 to 20 (Plate III.).

4. The latitude of anticyclone tracks varies with the season, being in latitude 37° to 38° in summer, and 29° to 32° in winter. See Table II. (p. 27).

5. Upon the average an anticyclone travels across Australia in 7 or 8 days in summer, and in 9 or 10 days in winter. Since 42 pass over each year, the average time of passage over any place is 8·7 days.

6. The average daily rate of translation derived from all the available records is, over Australia, 400 miles; and over the sea and land from Natal to Sydney, 458 miles. See page 28. The rate of translation of moving anticyclones varies from 200 to 550 miles over land.

7. The shape of the anticyclone over the comparatively flat lands of Australia is an ellipse, with axes in ratio of 2 to 1, the longer axis being east and west. The shape, as well as the direction of the major axis, are, as a rule, modified when the anticyclone reaches the east coast range, the result being a shortening of the major axis, and a bending of the major axis to or towards a position at right angles to what it had on the low lands, *i.e.* making it north and south. See diagrams 3, 4, 5, 6 and 7 (Plate II.).

8. The winds on the north side of the anticyclone are not so strong as those on the south side; but at the ends the winds have greater velocity, and the two winds, Northerly and Southerly, pass each other as if struggling to get through between two obstacles, *i.e.* the preceding and following anticyclones. See diagrams 1 to 8.

9. The intensity of weather is in proportion to the difference in pressure between the anticyclone and the V-depression, but the relation of the

pressures varies frequently *before* the wind responds, and it seems as if the pressure was controlled from above by the more or less rapid descent of air, which feeds the anticyclone. The centre of the descending current, assuming that to be the point of greatest pressure, not unfrequently moves about independently of the general motion, so that the centre at times seems to retreat, without corresponding motion in the extreme parts of the anticyclone.

10. When the V-depression is deep it is usual for the South-east Trade wind, blowing in the north of Australia, to be deflected into a Northerly wind in the rear of an anticyclone, which gets heated as it blows over Central Australia, and becomes the true hot wind of the Southern Colonies. This also explains the sudden shift from hot Northerly to the cold Southerly wind, blowing on the following side of the V-depression.

11. Cyclonic storms are very unusual, and do not appear more than once in two or three months. These come from north-east to east, or from the north-west coast across the Australian continent to the sea at the Great Bight, thence they travel eastward. They do not seem in any sense to be part of our weather system, but to be offsets from tropical storms.

The depression between anticyclones is essentially a V-depression, both in the shape of the isobars and the thunderstorms which mark the passage of the lowest pressure.

It is, of course, impossible here to pass in review all the 1,400 Weather Charts which have contributed to these deductions; and I have, therefore, selected for reproduction here a set of eight Weather Charts in which the passage of an average anticyclone is clearly depicted (Plate II.). The isobars have been reproduced on a convenient and small scale, and these show much better than any description what the ordinary sequence of events is. Attention may, however, be called to one or two points. No. 1 diagram shows the incoming anticyclone well established on the coast of Western Australia, with a passing V-depression in front of it extending over the southern parts of South Australia, Victoria, and New South Wales. No. 2 shows the 24 hours forward motion and the closing up of the isobars as they reach the east coast mountain range. Nos. 3 and 4 show the further progress of the high pressure and the decided effect of New Zealand mountains in intensifying the V-depression. No. 5.—As on Sunday we get no telegrams, *probable* isobars have been drawn. No. 6 shows the anticyclone over New South Wales, and the preceding end of its major axis tilted northwards by the mountains, while in Western Australia we see the first isobar of the incoming high pressure, and over Perth the V-depression which divides the two. No. 7.—The axis of the anticyclone is now nearly north and south, and it has passed over the mountains. No. 8.—The anticyclone is over the sea between Australia and New Zealand, and with its two axes nearly equal. Such is the passage of an ordinary anticyclone. This one was moving at the rate of 450 miles per day, which is somewhat above the average speed; and by referring to the diagrams it will be seen that its track is nearly straight, and from west to east. The majority of such anticyclone tracks are beset southwards in the middle as if

when the anticyclone reaches the west coast range, which trends to south-south-east, it is deflected so as to move to the east-south-east instead of east; and that when it meets the east coast range which trends to north-north-east the track is again deflected by mountains and made to go east-north-east or north-east. See illustrations of this in diagrams 11, 15, 17, 18, 19, and 20 (Plate III.).

Another feature brought out in the diagrams is the occasional stoppage of the anticyclone. For instance, in diagram 12, track C, the centre was about the same place from April 25th to May 1st. In No. 15 the track is remarkable, the anticyclone lasting 25 days, although it moved every day. Of its kind, this is the most remarkable one we have on record.

Out of a total of 42 anticyclones which passed over Australia in 1891, 6, or 15 per cent., hesitated or actually stopped in their forward motion. Table I. shows the number of cyclones in each month since February 1888.

TABLE I.—NUMBER OF ANTICYCLONES IN EACH MONTH.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1888	..	..	2	3	3	2	3	5	3	5	4	4
1889	3	4	2	3	4	4	3	3	4	4	4	5
1890	5	3	4	3	2	2	2	3	2	5	5	6
1891	4	4	3	3	3	4	2	4	4	4	4	2
1892	3	4	3	4	3	4	3	..	..	..	..	..
Totals	15	15	14	16	15	16	13	15	13	18	17	17
Mean	3·8	3·8	2·8	3·2	3·0	3·2	2·6	3·8	3·3	4·5	4·3	4·3

It is difficult to understand how an anticyclone can, to all intents and purposes, stand still for several days when the whole surrounding atmosphere is moving forward; and we have not yet made out the explanation. But facts, and some very significant ones, are accumulating which indicate the probable explanation. For instance, when such a stoppage occurs, the isobars in front widen out, showing that the preceding system is moving forward; and the closing up of the isobars in the rear shows that the following one is coming forward. We know also, as already pointed out, that the source of pressure, the descending current in the anticyclone, may, and does, vary in locality from day to day with regard to the outlying isobars, coming down at one time on the preceding side of the centre and at the next on the following side. This gives an oscillating position to the centre, and it is conceivable that the descending current might come down with such an inclination towards the west as to make its locality stationary with reference to land surface, and make it so by the continuous pouring down upon one place. But it seems impossible that a mass of air, even that in one anticyclone, without reference to its surroundings, measuring as it does 2,000 miles by 1,000 miles, can be actually stopped in its forward motion. This point is,

however, one of those still under investigation, and we hope in another paper to make the explanation complete.

In America it is well known that cyclones move 10 to 15 per cent. faster than anticyclones, but there the low pressure acquires a velocity of its own in addition to that which it has in common with the general mass. The conditions here, as already pointed out, are different, the low pressure not being independent, but tied to the anticyclone by the laws of its being as effect is to cause.

Another point of considerable importance is the normal latitude of the anticyclones in each month of the year. At times it is a very uncertain matter, for there is as much difference in the latitudes of tracks in the same month in some cases as there is in the average tracks for each month of the year. Still, taking the 4½ years of available records, there is a very obvious monthly change of latitude, which is best indicated in tabular form.

TABLE II.—Monthly Change of Latitude of the Anticyclones.

Months.	1888.	1889.	1890.	1891.	1892.	Mean Latitude.
	°	°	°	°	°	°
January	..	37	38	36	36	36¾
February	..	38	41	36	38	38¼
March	34	38	39	37	37	37
April	37	32	35	36	35	35
May	33	32	31	34	33	32⅗
June	27	27	27	37[1]	29	27½
July	27	30	30	29	33	29⅘
August	28	31	30	30	..	29¾
September	32	32	30	30	..	30½
October	33	32	29	33	..	31¾
November	38	37	32	36	..	35¾
December	39	37	35	35	..	36½

[1] Not included in mean.

It must be borne in mind that the tracks are seldom straight, and that at times they are very erratic. The above positions for each month have been obtained from careful eye estimates of the mean positions, and this must be borne in mind in using the table. The tracks for 1891, diagrams 9 to 20, will illustrate what I mean, and, I think, justify the course adopted in preference to that of taking the measured latitude of a series of points in each curve. The individual curves are too irregular for such a method.

It will be observed that the maximum of latitude is in February, a month after the hottest month; and the minimum in June, which is not our coldest month. Perhaps, however, June should be rejected from this attempt to determine the monthly latitude, because in that month, for some reason not obvious, the tracks are much more erratic than in any other month of the year, and it is almost impossible to take a mean latitude for it; and if it be rejected the minimum would be between July and August, July being our coldest month.

It is our experience that when an anticyclone track is far from the mean, the weather is also far from the mean. For instance, in June 1891 two

tracks were down in latitude 37° instead of 27°, and we had, as a consequence, 14½ inches of rain—an excessive quantity, the mean being 5¼ inches.

I have already stated that taking a large number of anticyclones on their passage over Australia the daily translation eastward is 400 miles; and it is a matter of considerable interest to ascertain if they maintain the same velocity of translation over the ocean. I have been so far unable to trace any connection between the variations in the barometers at Buenos Ayres and Sydney, and infer from this that the great mountain chain of the Andes so breaks up the anticyclones that the curves are not alike. The only other place in like latitude for which I have daily barometer readings, and these for only one year, 1890, is Natal. Fortunately there is an obvious similarity in the curves. I have compared these with Sydney by having the two plotted on the same scale and taking the difference in the times at which marked points of high and low barometer readings pass the two places. There are—

In January	5	cases with a mean of	18 days
February	5	,,	16
March	5	,,	15
April	8	,,	18
May	4	,,	12
June	3	,,	14
July	4	,,	16
August	5	,,	17
September	5	,,	14
October	4	,,	14
November	3	,,	17
December	5	,,	15
Total	51 cases	Average No. of days	15·08

The greatest number of days for the translation of the waves from Natal to Sydney is 18 days for April, which makes the daily velocity of translation 382 miles; the least number of days in any month is 12, in May, which makes the velocity of translation 573 miles per day. The average rate for all the months is 15 days, which is equal to a velocity of translation of 458 miles per day.

Taking individual anticyclones in Australia the slowest moves at 120 miles per day, and the quickest 550 miles per day, the average being 400 miles per day. The result of this comparison surprised me by the similarity of the two results. I do not, however, think that very much value should be attached to a comparison of barometer curves for one year only, still it agrees remarkably with that obtained by 4¾ years' results for Australasia, and the little difference is in the direction it ought to be, owing to the obvious friction of the land surface, mountains, &c. as compared with the smooth sea surface.

The two methods of determining the velocity of anticyclones, that is over Australia alone, where it is 400 miles per day, and over the space from

Natal to Sydney, where it is 458 miles per day, seem to leave no doubt as to their persistence. For if they can thus be followed one-third of the circumference of the earth, *i.e.* from Natal to Sydney, it may safely be assumed that they travel the other two-thirds of the way, and that they keep up their general characteristics. What influence the great obstacle in their path, the Andes of South America, may have on them I am not at present in a position to say, but I have no doubt, from what we see so clearly in the influence of our own comparatively small range of mountains along the east coast of New South Wales, that it is a very material one.

If from Buenos Ayres we could get by cablegram the state of the weather from day to day, we should be in a position to forecast the coming weather for about a month in advance; and it may yet be that when our investigations, which are now in progress, are completed we shall be able to forecast far longer periods. If, for instance, we could ascertain the velocity of the translation of the anticyclone round the other two-thirds of the globe, as we have done the one-third from Natal to Sydney, or rather more than one-third because it extends to New Zealand, then we could ultimately forecast the return of weather passing over Sydney. Certainly the discovery of the daily translation of anticyclones in our latitude, over such a large section of the circumference of the globe, holds out a reasonable hope that they may be traced all round, and the prevalence of water points clearly to the fact that the conditions are more favourable here than in any other part of the earth for normal atmospheric circulation. I do not by this intend to convey the idea that I think an anticyclone keeps its shape, size, form, and peculiarities for weeks at a time, because I see them changing every day. But there are obvious peculiarities which affect a number of anticyclones—general characteristics I mean, such as dryness or moisture, —which, it may be, attaches to them more persistently than the mere form of the isobars. And if so, it will afford good data for long period forecasting.

If I have succeeded in showing the normal conditions of our weather, as that of an endless series of anticyclones passing over to the eastward at the average rate of 400 miles per day and keeping within a very moderate range of latitude, it will be obvious that these conditions hold out the prospect of our being able to predict the weather for some weeks in advance; because an anticyclone with such a rate of motion in latitude 38° south would pass round the earth in 49 days (7 weeks). It is true that in isolated anticyclones we find the rate of motion vary considerably over a part of its track; but I think it is a fair assumption to make, that the average velocity of the anticyclones, in a given latitude, is the rate of progress of the atmosphere at that latitude, and that the apparent variations in rate are simply local accelerations or retardations, which would naturally affect masses of air in motion under several influences, that is the translation, the constant variations in pressure, temperature, &c. As already stated, the anticyclone in passing over Australia manifests characteristics which make our weather wet, stormy, or fine, and further that the character may, and sometimes does, change during its progress.

But there are characteristics, such as a succession of dry or wet periods, which do persistently affect a number of anticyclones. It is quite possible that indications of such characteristics may be found and be valuable in forecasting for some weeks in advance; and also that we may find upon further investigation, that there are more definite and valuable characters, which can be in some cases discovered in individual anticyclones, indicating their persistence and recurrence.

Many points could be decided if one could ride in the car of a balloon on top of an anticyclone during its seven weeks' journey round the earth, making notes of weather and places passed. And were it not for South America it would be possible to watch an anticyclone passing over Australia and New Zealand, and having there a fast steamer which should start at once in the front of the high pressure, and make her way in it round the earth. Such methods are impossible until the world wakes up to the real value of weather knowledge, but when it does the weather could be followed by having a second steamer at Buenos Ayres to take up the journey after the first one parted with it at Valparaiso. In the meantime we are collecting such information as can be obtained from passing ships.

DISCUSSION.

Capt. TOYNBEE, in a letter to the Secretary, said :—

"As I very seldom attend evening Meetings now, perhaps I may be excused for saying a few words in this letter on the subject of the paper.

"Natal, Australia, and New Zealand seem to lie in a more southern latitude than that of more permanent high pressure which is supposed to lie to the southward of the South-east Trades. These countries are therefore influenced by the northern sides of the cyclonic systems which pass to the eastward along the southern side of the more permanent area of high pressure, which northern sides are perhaps well represented by these waves of high pressure having the northern parts of systems of low pressure between them. The diagrams seem to support this theory.

"I have often thought it would be interesting to know what takes place between the travelling systems of high and low pressure in the North Atlantic and the more permanent area of high pressure which lies north of the North-east Trade. Perhaps an examination of our Atlantic Charts might reveal some truths on the subject. I am not able to go into that myself.

"The large amount of water in comparison with land in the Southern Hemisphere would most probably lead to more regularity in the motion of these waves than may be found in the Northern Hemisphere. This very interesting paper seems to throw some light on the subject, and I hope it may lead to more work in the same line in both Hemispheres."

Mr. SCOTT said that the isobaric lines shown on Mr. Russell's charts were apparently based on very few observations; there were, as far as he knew, only four or five stations over the whole of the interior of Australia, so a good deal of imagination must be involved in drawing the numerous isobars shown on the maps. He would like to know how Mr. Russell had calculated the motion of the anticyclones, and what was considered the centre of these areas, as in the Northern Hemisphere, at any rate, the centres of anticyclones were very ill defined, owing to the generally irregular shape which the isobars assumed. He then read the following extract from a brief report dealing *inter alia* with the motions of anticyclones over the Atlantic Ocean, published in the *Report of the Meteorological Council to the Royal Society for the year ending March 31st*, 1889, entitled "Notes of some Results of an Examination of the Atlantic Charts published by the Office," pp. 25-26 :—

"An attempt was also made to study the anticyclones or areas of high barometrical readings. It seemed impracticable to study the position of the entire areas enclosed on each day by the isobars of 30·0 ins., or even of 30·1 ins., as these frequently embraced nearly the entire area of the maps. The isobar of 30·2 ins. was then selected, as indicating the regions where the excess of barometrical pressure was most strongly accentuated, and as enclosing areas which were manageable.

"A map was then drawn for each day on tracing paper showing the positions of these areas. These maps were then combined for successive days, by the method of a sort of composite portraiture, and the several areas for the different days were drawn in different coloured chalks, the same sequence of colour being preserved throughout, and the last chart of each series being always reproduced as the first of the next.

"It was found that, as a general rule, not more than three days could be combined without confusing the pictures.

"These combination maps were then again combined in order to see what evidence was procurable of movement of the areas of excessive barometrical pressure (those of 30·2 ins. and upwards) in the middle latitudes of the charts. It was not apparently of importance to trace those north of latitude 60° or even those over Europe, as both of these classes frequently passed beyond the limits of the charts.

"Thus much, however, has become apparent, that the area of excessive barometrical pressure, the Atlantic anticyclone, which lies over the Atlantic to the westward of the Canary Islands for the greater part of the year, is constantly being replenished by travelling anticyclonic areas which advance slowly from the westward. They move, therefore, in the same general direction as the cyclonic disturbances, the depressions, but at a much slower rate.

"The number of such areas that have been definitely traced as advancing from the western portion of America to the Central Atlantic during the 13 months is 15, and the dates of their first appearances are as follows:—

1882.	August 30		1883.	March 9
	September 13			April 2
	October 6			" 8
	" 16			July 17
	" 25			August 1
	November 29			" 13
	December 4			" 25
	" 9			

"It will be seen that no motion of the nature indicated above was noticed between the middle of December and the beginning of March, nor again during May or June.

"As regards these periods, during the winter the belt of readings above 30·2 ins. generally stretched across the Atlantic from Africa to North America. In January this was occasionally interrupted, but from February 1st to 21st there was hardly any change noticeable in this anticyclonic area, as far as the portion lying over the Atlantic is concerned.

"As regards the second period, the reason that no anticyclones started from America to travel eastwards at that time is apparently that during the month of May, and June particularly, there was hardly a day on which areas of 30·2 ins. showed themselves over the United States.

"In conclusion, it must be said that the endeavour to connect paths of anticyclones with paths of cyclonic disturbances at the same date by any obvious relation such as parallelism, &c., has not been successful."

List of the Anticyclones which apparently crossed the Atlantic between August 1st, 1882, and September 3rd, 1883.

1882, *August* 30. An anticyclone appeared over the eastern coast of Virginia and the New England States, and moved eastwards slightly on the 31st and September 1st. It was traceable but not distinctly marked out on the 2nd, but reappeared on the 3rd, and on the 4th merged in the eastern Atlantic system.

October 6. An anticyclone which had been lying for several days over the Eastern States of the Union, began to move eastwards. It advanced very slowly and finally died out on the 16th, near the Canary Islands.

October 16. An anticyclone showed itself in two small patches, one over Nova Scotia, the other out to sea. This latter advanced rapidly, between the 18th and 20th to the central Atlantic, west of the Canaries. There it was subsequently joined by another which had appeared over British Columbia on the 16th, and had also crossed the ocean. The two coalesced on the 24th, and remained in the same position till the 29th, when the system grew smaller, moved eastward, and finally passed out of view over Algeria on November 1st.

October 25 An anticyclone, which had possibly come from the north-west, appeared over Florida, October 25th. It moved northwards and then across the Atlantic, and on November 1st stretched across (in latitude 40°) from Spain to longitude 70°. It finally extended eastwards and lay over Europe for several days, combining with one which appeared over Lapland on the 2nd, and advanced southwards to meet it, lasting till November 4th, when it disappeared.

November 28. A large anticyclone lying over the American lakes threw out an arm over Nova Scotia. This broke off and travelled rapidly across, joining the eastern area December 1st.

December 4. The same process was repeated, a portion of the American anticyclone separated itself from that continent and crossed the Atlantic, joining this latter area on the 5th. On the 6th a large anticyclone stretched nearly across the ocean. Subsequently it drew more to the eastward.

December 9. An anticyclone lying over Bermuda moved eastwards, and reached the central Atlantic on the 13th, when it became very small. It was followed by another, which on the 13th exhibited two separate areas, off the American coast, which died out there. The original anticyclone grew larger, and about the 21st passed over to the coast of Africa, where it finally disappeared at the end of the month.

1883, *March* 9. A small anticyclone disengaged itself from the American continent and travelled across to near the Cape Verdes. It was followed by another, starting on the 12th, which joined it on the 15th, and then the two remained in the same district for 5 days.

April 2. An anticyclone appeared over the American lakes and crossed eastwards to the central Atlantic, where it remained till the 9th, when it became very small.

April 8. An anticyclone appeared over the States and advanced eastwards until the 10th, when it lay in 60° W. On the 11th it joined with another which had been over the United Kingdom on the previous day. This joint area remained in the same region until the 22nd, moving slightly eastwards.

July 17. An anticyclone appeared near Fort York, and moved south-eastwards till on the 21st it was swallowed up in the Atlantic anticyclone which had stretched out westwards.

August 1. An anticyclone which had been lying near Fort Simpson began to move southwards, and advanced very slowly until it was swallowed up on the 13th. It is traceable on every day except the 9th.

August 13. An anticyclone appeared over Lake Simpson, and moved steadily eastwards till it joined the Atlantic anticyclone on the 16th.

August 25. Another anticyclone, similar to that last named, appeared near Lake Athabasca, and advanced till it too was swallowed up in the Atlantic anticyclone on the 30th.

Mr. SCOTT also showed by means of seven daily charts for October 18th to 24th, 1882, what changes and movements took place in the anticyclonic areas prevailing over the North Atlantic during the week selected. He considered that a great deal more information than Mr. Russell had available would be required to prove the case which he (Mr. Russell) appeared to think he had made out.

Mr. C. HARDING said that there appeared to be a considerable difference between the tracks given on Capt. Hepworth's maps, and those shown on Mr. Russell's maps. During the summer months Mr. Russell should have given the tracks of the anticyclones further to the southward of Australia, as Capt. Hepworth had shown. It was to be regretted that Mr. Russell, while making

absolute statements concerning the movements of anticyclonic areas, did not supply proofs of the correctness of such statements, or show how they were obtained. Mr. Russell had supposed that anticyclones travelled from Natal to Australia, but, in his (Mr. Harding's) opinion, a careful study of meteorological charts for that region showed that anticyclones never moved in the manner he supposed. The charts of atmospheric pressure in these regions, prepared by Lieut. Baillie of the Meteorological Office, indicated that in the high pressure areas there was no range in barometrical pressure, which was good proof of the permanency of the anticyclone. Areas of low pressure were never found within the limits of the region covered by these anticyclonic areas, but on either side of these areas the presence of low systems was very apparent. Mr. Russell stated that in Australia the anticyclones were five times as long in duration as cyclones: he (Mr. Harding) thought that it would be interesting to know if this were really the case, as it was certainly not so in the British Isles, otherwise we should enjoy five times as much fine weather as wet weather. The late Prof. Loomis, who had devoted a great deal of attention to the study of areas of high pressure over the globe, had stated in Chapter II. of his revised edition of *Contributions to Meteorology* that the higher the pressure in these anticyclonic systems the more southerly was their track. Loomis did not deny the existence of permanent areas of high pressure, but he had chiefly discussed the moving systems. It had been generally believed that Westerly winds prevailed almost exclusively in the Southern seas, south of Australia, but recent research had shown that this belief was erroneous, as Easterly winds were frequently prevalent.

Rev. W. Clement Ley, in response to the request of the President, said that only having heard a part of the papers under discussion he was not able to offer any remarks upon them, but he was certainly inclined to think, with previous speakers, that the results put forward were based upon too small an area of observations.

Mr. Harries pointed out that Mr. Russell had fallen into the error of supposing that because areas of high pressure passed across Australia from west to east, therefore they must have maintained their independence and travelled more or less steadily all the way across the Indian Ocean from South Africa. In his own opinion there was no justification for such an assumption. What really took place was no doubt analogous to what occurs in regions bordering on the North Atlantic. Mr. Scott had limited his remarks to the feeding of the Atlantic permanent anticyclone by other areas of high pressure advancing from the westward, but a glance at the diagrams enabled us to say that at the same time the permanent area becomes elongated in an easterly or north-easterly direction, until finally a portion is detached and on the last diagram such an area is shown over Algeria, while the parent area maintains its position out on the ocean. This process of absorption on one side, and of expulsion on another, is constantly going on, many, probably most, of the European high pressure systems being offshoots of what we know as the permanent anticyclone. As to the idea of connecting together the barometrical variations at Natal and Sydney, without considering the conditions over the intervening sea space, he (Mr. Harries) would remind the Fellows that four years ago a Fellow of the Royal Astronomical Society announced in the *Times* that he had discovered that the fluctuations of the barometer in London were repeated in Jamaica seven days later, and that consequently the West Indies should be warned from the Metropolis of the approach of weather changes!

Prof. Laughton inquired whether the remarkable tracks shown in Mr. Russell's map for July were to be understood as having been laid down from actual observations. He had no idea that there were so many barometric stations in the interior of Australia, as this map, more particularly, seemed to imply.

Mr. Inwards inquired how many observations were utilised in the preparation of the charts of the North Atlantic shown by Mr. Scott.

Mr. Scott said that about 1,000 observations (600 over North America and Europe, and 400 over the sea) were used every day in the preparation of the daily charts, for the 13 months, August 1882—August 1883 inclusive, published by the Meteorological Office.

Mr. Strachan said that he thought that Mr. Russell had fallen into error in thinking that the anticyclones travelled to Australia from Natal, but was

right in stating that the high pressure areas came into Australia from the westward.

Capt. WILSON-BARKER said he thought the title of the first paper was misleading, as it dealt only with the rate of the anticyclones over Australia. It must be remembered that the rate of translation of anticyclones might be considerably increased by the land influences. He was quite in accord with the opinions expressed by other speakers as to the permanence of the oceanic anticyclones, though these vary considerably in size. He thought the papers were valuable, as it was by the aid of such papers that we could extend our knowledge of meteorology.

Mr. SYMONS said that the allegations against Mr Russell's paper seemed to be that the charts were a grand illustration of the scientific use of the imagination, because they were founded on so few observations. But it must be remembered that these observations were the best obtainable. He believed that each chart showed approximately the general atmospheric conditions prevailing over Australia during the period to which it referred, and that the conclusions based upon hundreds of them were sound. When the difficulties with which both Capt. Hepworth and Mr. Russell had had to contend were considered, he thought that the work they had accomplished was creditable and that future researches would prove it to be valuable.

THE TRACKS OF OCEAN WIND SYSTEMS IN TRANSIT OVER AUSTRALASIA.

BY CAPT. M. W. CAMPBELL HEPWORTH, F.R.Met.Soc , F.R.A.S.

(Plate IV.)

[Received October 3rd—Read December 21st, 1892.]

As an aid to the study of air circulation on the south and south-east coasts of Australia, I obtained for the year ending September 5th, 1891, the daily Weather Charts of Australia and New Zealand, prepared at the Sydney Observatory under the direction of Mr. H. C. Russell, F.R.S., the able Government Astronomer of New South Wales.

I hoped from an examination of these records to ascertain the positions of the centres of high and low pressures from day to day, and also, if possible, to obtain a mean from the tracks thus deduced; and when my investigation was completed, it occurred to me that the results, imperfect though they be, might prove interesting to the Fellows of this Society.

The observations recorded in the Weather Charts are made at 9 a.m., local mean time, and the maximum number of stations at which they are taken is 74; but over such a vast area, observations from even twice the number of stations would be quite inadequate for the evidence required, and, moreover, consequent upon the occasional interruption of telegraphic communication, observations from many stations are sometimes not obtainable, particularly from those in the west and north-west. It is to be regretted that the observations are not taken synchronously, as the difference of time

between the eastern and western stations is considerable. It is also unfortunate that no charts are published for Sundays.

The frequent dotted lines on these charts, indicating interpolated and assumed isobars, make any attempt at absolute accuracy in determining the positions required impossible.

From such data, then, the approximate positions of the centres of high and low pressure have been deduced; and delineated on four maps, two of which deal with the four winter months of May, June, July, and August; and two with the five summer months of November, December, January, February, and March (Plate IV.). The months of April, September, and October, during which the distribution of atmospheric pressure over Australasia is undergoing a change, and at times produces features which are characteristic both of the winter and summer seasons, have been omitted.

In the maps devoted to low pressure the assumed approximate centres are shown by dots, and when it has been possible to trace the progress of a system the dotted daily positions have been joined by lines, an arrow marking the spot where the depression was last charted, before being lost to recognition. The same plan has been adopted in preparing the high pressure maps, with the exception that the approximate centres of high pressure are shown by small rings instead of dots.

In fixing the positions of these centres I have generally adopted Mr. Russell's conclusions and interpretations of the isobaric lines, but occasionally another rendering has been chosen. In most cases the positions assigned to the centres of low pressure to the south of Australia and New Zealand may be too far north—their true positions certainly are not further north—and in the north of Australia too far south—they are not further south. Similarly the positions assigned to the centres of anticyclones approaching Australia from the south-west may be placed too far to the north-east, but their true positions have certainly not a more north eastward situation.

During the winter months, when pressure over Australia is relatively high, the centres of cyclonic disturbances, repelled by the higher pressure, take a more southerly path than obtains during the summer months; and during the four months under notice, two instances only are recorded of the centre of an invading depression "effecting a landing," so to speak.

During the summer months likewise, the cases in which centres of low pressure, advancing from the westward and south-westward, have taken a course across the land are few; for, as a rule, the low pressures situated in the north are not progressive; the weather being at this season to some extent monsoonal; the Arafura and Timor seas being under the influence of the North-west monsoon.

The wind systems, which make their first appearance to the westward and south-westward, advance to the eastward rapidly, and frequently very rapidly, during the winter months: but during the summer months they usually move more slowly and not unfrequently recurve. Their progress is retarded, of course, by contact with the areas of high pressure which they encounter; the

mean of the tracks of these anticyclones, moving also from west to east, appears to be across the southern portion of Australia and onward, crossing the islands of New Zealand, during the winter months; but to the southward of West and South Australia, across Victoria and New South Wales, and thence to the north-eastward, avoiding New Zealand, during the summer months.

The oft recurring phenomena of an axial motion of the isobars in their transit across Southern Australia, and more especially on their near approach to the eastern seaboard, has been pointed out to me by Mr. Russell. These belts of equal barometric pressure frequently assume the contour of the coast line, forming an ellipse extended in an east and west direction.

The coast ranges appear to act as a barrier, and the system is consequently often found to turn on its axis, the ellipse gradually becoming extended north and south, and the isobars closing until, by the advancing low pressure, the system is forced to the eastward and north-eastward over the Pacific.

Each eastward advancing area of low atmospheric pressure is, I believe, consorted with an area of high pressure, which, on approaching the coast of Western Australia, becomes merged in the anticyclone, which may be considered normal over that Colony during the winter months, with the result that the progress of the system eastward is considerably retarded.

During eight months of the year the prevailing winds on the steam route between Bass Strait and Cape Leeuwin are Westerly; but Easterly winds often blow steadily for days from the middle of December to the middle of April; (the sea immediately to the southward of the Great Australian Bight being under the influence of an anticyclone), and continue until the influence of the higher pressure to the southward is overcome by the encroachment of an area of low pressure. During the winter months the only Easterly winds that are experienced blow in the van of areas of semi-cyclonic origin, freshen when the wind has veered by North to North-west, and blow home from West-south-west to South-west, unless the approach of another disturbance, advancing from the westward, checks the increase of pressure, and thereby causes the wind to fall light and to back to the Northward, from which quarter it will again freshen with a falling barometer.

For weeks the wind will veer and back between North and West, each succeeding wind system asserting its influence in transit until a temporary cessation in the invasion occurs, when the wind veers to Southward.

The check given to these semi-cyclonic systems in their course eastward by the areas of high pressure, situated over, or immediately to the southward of, Southern Australia, which they overtake, is patent to all observers who make the passage to Bass Strait by the Cape of Good Hope route in a full powered steamer; for whereas wind systems fallen in with between the meridian of the Cape of Good Hope and that of Cape Leeuwin are rarely overtaken and passed, they are frequently outrun between the latter meridian and Bass Strait, the wind backing, and the barometer rising steadily; but the same observer will, soon after the steamer's arrival at the first port of call, renew his acquaintance with the overtaken wind system. Mr. Russell has

calculated the mean velocity of these wind systems to be about four hundred miles per day. I am, however, only stating my experience of their occasional low rate of motion. To those who navigate the Australian coasts, the probability of a change of wind off its south-easternmost point, *i.e.* at Cape Howe or Gabo Island, is well known.

The tendency of the wind on the south-eastern coast is to flow parallel with the land, as the general distribution of pressure over Australasia would lead one to expect.

During all seasons of the year Northerly or North-easterly winds are experienced on the coast of New South Wales and Southern Queensland, while the trough of depressions to the southward of South Australia, and passing across, or to the southward of Victoria, are still to the westward of the 150th meridian.

In winter, owing to the greater rapidity with which such systems travel eastward, these Northerly and North-easterly winds are short lived during this season; but during the summer months, when the mean pressure over the land is lower than that over the adjacent sea, and when the low pressure systems move more slowly, they blow for many days, pressure giving way or having a tendency to give way all the time, until the trough having passed eastward, the wind shifts in what is colloquially known as a "Southerly Buster."

The salient features in air circulation—the changes of wind and weather, and the progress of gales along the shores of Australia—have been accurately described in the *Australian Directory*, and it is not the purport of this paper to deal with that portion of the subject further than is requisite for exemplification.

In my paper, read before this Society in December 1890, dealing with the track of wind systems in their transit across the South Indian Ocean, I contended that the centres of these wind systems travelled to the eastward on a more polar path during summer months than in the winter. A survey of Mr. Russell's daily Weather Charts appears to bear out this theory.

The experiences of voyages made by me to Australia *via* the Cape of Good Hope, subsequent to that date, have tended to confirm me in the opinion I had formed; for in running down the easting in July (winter month) of last year between the 44th and 45th parallels, gales commenced at North, blew hardest at North-west, and moderated with a sudden shift of wind to West; while in July of this year (1892), when running down the easting between the 45th and 46th parallels, gales commenced at North-north-east, blew hardest at North, and moderated at North-west. In the same parallels during the summer months, no gale in my experience has blown home from any point to the northward of north-west, and rarely to the northward of west; but as a rule, the strongest blow has been experienced from some point to the southward of west. It is noteworthy that in the South Indian Ocean the strongest gales near the centre of a wind system blow on its left front between north-east and north-west with a rapidly diminishing pressure, the wind moderating and pressure increasing as the wind veers to the westward,

whereas gales circulating at a position in the storm-field remote from its centre, blow hardest from some point to the southward of west when the centre has passed, and the pressure is rapidly increasing; the wind having been comparatively moderate from some point, or points, to the northward of west, when the mercury was fast falling. In other words the wind blows hardest with a falling barometer in front of a wind system near its centre, but with a rising barometer in rear, remote from its centre.

The foregoing remarks upon the track of wind systems across the South Indian Ocean have been introduced, because not altogether irrelevant to the subject of this paper, and because it is hoped that information of any kind concerning the meteorology of any portion of the desolate Southern Seas may be acceptable.

A NEW INSTRUMENT FOR CLOUD MEASUREMENTS.

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[Received July 30th.—Read December 21st, 1892.]

In the *Annuaire de la Société Météorologique de France*, Tome XXXVI, 1888, p. 163, Mons. Lettry,[1] in consequence of a paper which I printed there on our cloud measurements, proposes a new kind of measuring instrument, which is really a "cloud equatorial." Though, at present, I have no time to spare on practical work in this matter, yet, as cloud measurements were taken up as an international enterprise by the Meteorological Conference in Munich last year, I think it desirable to discuss the best methods for such measurements. This is my reason for giving here a brief sketch of the theory of this cloud equatorial. It will serve equally well for the photographic or eye-observation method. The adjustment of this instrument, and the making and calculation of the observations obtained by means of it, will be simpler than if the theodolite type were used; nor will it I think cost much more.

As to the theodolite employed for our cloud measurements, I have already communicated a short paper on it to this Society.[2] It may be observed that the formulæ there given hold good only as long as the vertical axes of the two theodolites are very nearly parallel, which will be the case if they are not too distant from each other.[3] Suppose, for instance, this distance to be a nautical mile,

[1] Note sur une modification à la méthode de M. Nils Ekholm.

[2] Some methods for cloud measurements. *Quarterly Journal*, Vol. XIV, p. 124.

[3] This is also said in our paper: Mesures des hauteurs et des mouvements des nuages p 5. note 1,

then the inclination of the axes will be 1′, and may not be neglected in the case of very exact measurements. Thus if the base length is taken as large as 2 or 3 nautical miles, which will be a suitable base for measuring accurately the height and velocity of cirrus clouds, the inclination being 2′ or 3′, our formulæ ought to be corrected for it, or else the axis of the one instrument must be inclined by that angle towards the other in their common vertical plane, in order to make the axes parallel. But the former proceeding will complicate the calculation, and the latter will involve practical difficulties. No such difficulties will be found by using the equatorial type. But the greatest advantage of this instrument will be that it diminishes very much the difficulty of finding identical cloud points, the observers always being able to direct the sight-lines in the same plane.

Mons. Lettry states the principle very clearly thus: Let us have an indefinite plane moveable around the straight line AB joining the two stations A and B (figure 1). Let this plane at first coincide with the horizontal plane ABH and then be turned up to *touch* the cloud in a point C (in some exceptional cases there may be more than one such point, but they may in most cases be surely identified by means of telephonic communication).

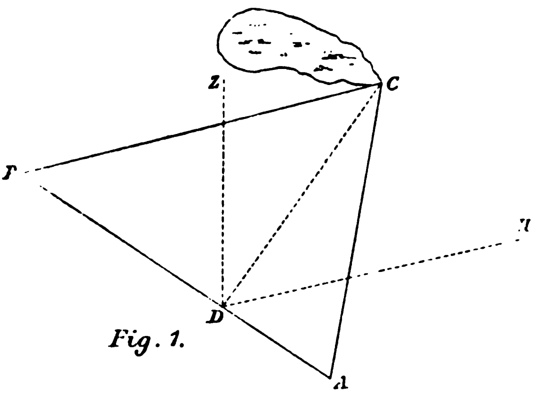

Fig. 1.

The angular height HDC or its complement the zenith distance ZDC will be read on the circles of the instruments, and will be equal when the instruments are properly adjusted. Also the angles BAC and ABC will be read on another pair of circles; and hence the rectangular coordinates of C may be easily calculated. It will not be necessary, of course, to make the plane ABC *touch* the cloud, it may cut the cloud, and yet the observers will generally be able to identify a point; or they may, if they please, determine a cloud point by means of telephonic communications only, and then aim at it without knowing beforehand the angle HDC; but immediately after they will read their circles, and then, if they have not very nearly the same value of this angle, they will have failed to find the same point. This is a very great advantage, as Dr. Hagström and I have had a great number of failures, the observations having to be rejected afterwards when we came to make the

calculation, and more than once we have been obliged to give up the work, as we could not agree at all on which was the same point of the cloud.

Figure 2 is a sketch of the instrument as I think it may be constructed.

The axis AB rests on shaped Y bearings in an iron frame supported by three levelling screws. A divided circle C, fixed on the axis, and an index with vernier, fixed on the frame at B, enable us to read the angle described by turning the axis. A level L is also fixed above the index on the frame parallel to C or perpendicularly to AB. Another level (not represented in the figure) may be placed on AB in order to adjust it horizontally.

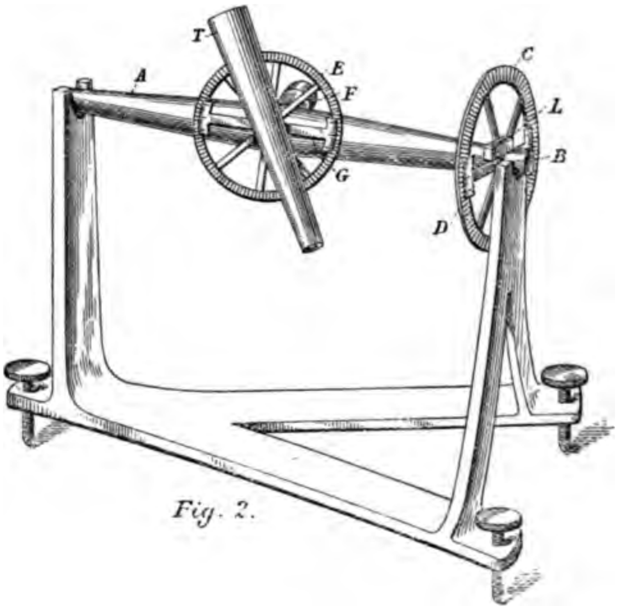

Fig. 2.

AB is pierced in the middle perpendicularly to its length by a cylindrical hole, through which a second axis is introduced, supporting the tube T and the circle E. These are balanced by a counterpoise F, which may be replaced by a photographic camera. An index with vernier G fixed on AB enables us to measure the angle between AB and the sight-line of T. By means of two pairs of tongs provided with clamp screws (not represented) the axes may be fixed ; and these tongs may have a finer adjustment screw.

By means of simple manipulations, well known through the theory of astronomical instruments, the equatorials may be adjusted.

1. The sight-line of the tube T must be in a plane parallel to AB (or in other words there must be no collimation error). For this, the axis AB and the axis supporting T must be perpendicular to each other, and the latter axis must be perpendicular to the sight-line of T.

These two adjustments may be performed thus ;—a distant mark is set up

approximately in the prolongation of BA, the tube T is directed to it and clamped in that position.[1] Then AB is turned round 180° on its axis.

Now if the sight-line be exactly parallel to AB, it will still be directed on the mark. If not, another similar mark is set up in the latter direction; then the exact point of prolongation of AB will be midway between the two marks. One of the marks having been placed there, the sight-line must be exactly directed on it by means of the adjusting screw of the vernier and those of the cross thread.

Now the axis supporting T is turned through 180°, and thus the sight-line directed from A to B. A mark is set up in the prolongation of AB, and, as just shown, adjusted so as to be exactly in that line. Then, if the two axes of rotation be exactly perpendicular to each other, the sight-line will be directed on this mark also, and the instrument will be adjusted. If not, the sight-line must be adjusted so as to be on the mark, the one half of the deviation being taken away by adjusting the cross thread, the other half by adjusting the axis supporting the tube, by means of screws adapted for displacing slightly one of its bearings.

These operations must be repeated until the sight-line of the tube remains directed on the first or second mark, when AB is turned round. Then the adjustment is completed.

2. The index errors of the circles must be determined and, as nearly as possible, eliminated.

The zero point of the circle C may conveniently correspond to the position of the sight-line of T in the vertical plane, the air bubble in the level L being at its middle point. The index error is found by sighting with T at a distant object approximately situated in a direction perpendicular to AB, reading the circle C and the level L, then turning T as well as AB through 180,° sighting at the same object and reading again. This error may be eliminated if there are adjusting screws to displace the index or the circle.

The zero point of the circle E must correspond to the position of T parallel to AB, and the index error is immediately found by reading the circle after the collimation error is got rid of, as shown in 1, and it may be eliminated[2] in the same way as the former error.

3. The angle formed by AB with the horizon (*inclination*) must be determined.

For this, placing at first AB horizontally by means of the level placed on it (adjusting the level in the ordinary way and thereby determining the inequality of the pivots, if such exist), the sight-line of the tube T is set also

[1] This mark may conveniently be a circular disc, the radius of which is equal to the distance of the tube from AB. Then if the sight-line be directed on a convenient point of the circumference of the disc, the effect of the eccentric position of T in respect to AB will be eliminated.

[2] Other instrumental errors may be neglected if the instrument is carefully made, viz. *error of eccentricity*, because there are two opposite verniers, *error of division*, because a greater accuracy than 0°·01 is not needed, *error of flexion*, because the instrument must be very strong and rigid.

horizontally by means of the circle, or, as described in 1, by means of a mark. This mark will also serve for the last adjustment. As will be shown in the next moment, a certain angle of inclination must be given to the axis AB, and in order to do this the axis must be made to form that angle with the sight-line of AB by means of the circle E, and the instrument then adjusted by means of the foot screws, so as to make the sight-line again horizontal, the horizontality being controlled by the mark.[1]

4. Lastly, two of these equatorials must be placed in a proper position, so that their axes are in a straight line, which should be horizontal, if possible, because the adjustment and calculation are then easiest. If the instruments are visible from each other, this may easily be done by two observers operating simultaneously. If not, the position of their common vertical plane must be found and indicated by a mark for each instrument. Also their rectilinear distance and difference of altitude must be determined by triangulation and levelling; then the inclination that must be given to the axes, in order that they may be in a straight line, can be easily calculated, and the last adjustment performed as shown above. These adjustments are not more difficult and laborious than those one must perform when using theodolites, if these instruments are not visible from each other. Of course, the azimuth of the base must also be determined, according to well-known methods.

Thus the instruments are placed and made ready for use.

As to the form of the foot-frame represented in Fig. 2, it may perhaps advantageously be modified. This frame must, of course, be large enough, so that the observer has sufficient room for his head and arms during the observations. Perhaps the best plan will be to divide this frame into two parts supported by two different stone piers, between which the observer may comfortably place himself. In this case the levelling screws may act on special pieces sliding in the frame.

Formulæ for Calculation.—In order to calculate the rectangular coordinates of the cloud point C (Fig. 3) let the one instrument A be taken as origin, let the axis of x be the line AB joining A to the other instrument B, taken positively in that direction, let the axis of y be the horizontal line AY perpendicular to AB, taken positively to the right, and the axis of z perpendicular to these axes, and positive upwards.

The angles $Z^1DC = \delta$, $BAC = \alpha$, and $ABC = \beta$, being given by observation and the base length $AB = b$ being known, we easily find

$$\left.\begin{aligned} AD = x &= \frac{b \sin\beta \cos\alpha}{\sin(\alpha+\beta)} = b - \frac{b \sin\alpha \cos\beta}{\sin(\alpha+\beta)} \\ DE = y &= \frac{b \sin\alpha \sin\beta \sin\delta}{\sin(\alpha+\beta)} \\ EC = z &= \frac{b \sin\alpha \sin\beta \cos\delta}{\sin(\alpha+\beta)} \end{aligned}\right\} \quad \ldots \quad \ldots \quad (1)$$

[1] This adjustment may also be made by means of the levelling screw at A, if the distance between its thread windings be exactly measured.

These formulæ will suffice, if AB be horizontal; if not let AX_1, drawn horizontally from A in the vertical plane of AB (or AX), be taken as the axis of X, the vertical line AZ_1 as the axis of Z, while the axis of y remains unaltered. Let the angle of inclination BAX_1 (or DAD_1) taken positively upwards, be called γ; then we will have

$$\left.\begin{aligned} AD_1 &= X_1 = x\cos\gamma - z\sin\gamma \\ D_1E_1 &= Y \ = y \\ E_1C &= Z_1 = x\sin\gamma + z\cos\gamma \end{aligned}\right\} \dots \dots \quad (2)$$

The formulæ (1) are very convenient for logarithmic calculation. The formulæ (2) may be easily tabulated, as γ is a constant.

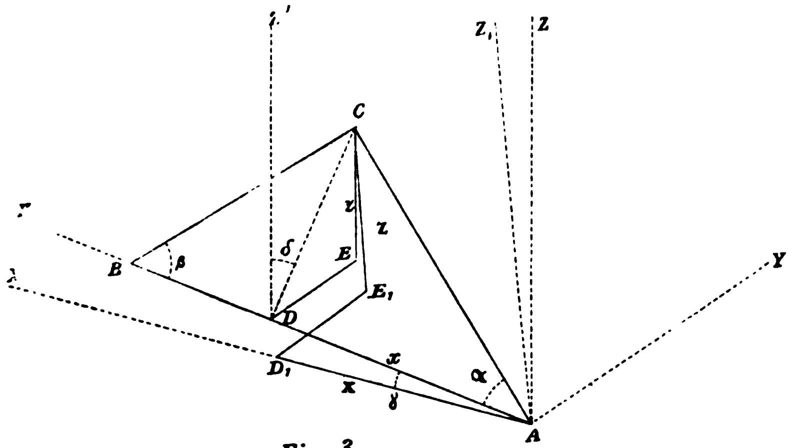

Fig. 3.

If the observers use the last method above mentioned, the sight-lines of their tubes may not be exactly in the same plane; then the most accurate method of calculation will be to determine the coordinates of the middle point of the shortest distance of the sight-lines. Though the formulæ for this case may perhaps not be needed, yet as they are simpler than the corresponding formulæ for theodolites used for our calculations (*loco citato* p. 129), I shall give them here.

Let C_1 and C_2 be the points at which the two sight-lines meet, respectively the line of their shortest distance; x_1, y_1, z_1, and x_2, y_2, z_2, the rectangular coordinates of those points and x, y, z those of their middle point C, the axis of coordinates being taken as above in (1). Let δ_1 and δ_2 be the values of δ (Fig. 3) corresponding to the sight-lines $AC_1 = r_1$ and $BC_2 = r_2$; let θ be the angle between them. Then we shall find:

$$\operatorname{Sin}^2\frac{\theta}{2} = \cos^2\frac{\alpha+\beta}{2} + \sin\alpha\sin\beta\sin^2\frac{\delta_1-\delta_2}{2} \quad \dots \dots \quad (3)$$

and

$$\left.\begin{aligned} \frac{r_1+r_2}{2} &= \frac{b}{4}(\cos\alpha + \cos\beta)\operatorname{cosec}^2\frac{\theta}{2} = \frac{b}{2}\cos\frac{\alpha+\beta}{2}\cos\frac{\beta-\alpha}{2}\,.\operatorname{cosec}^2\frac{\theta}{2} \\ \frac{r_1-r_2}{2} &= \frac{b}{4}(\cos\alpha - \cos\beta)\sec^2\frac{\theta}{2} = \frac{b}{2}\sin\frac{\alpha+\beta}{2}\sin\frac{\beta-\alpha}{2}\sec^2\frac{\theta}{2} \end{aligned}\right\} \dots \quad (4)$$

By means of (3) and (4) r_1 and r_2 may be calculated, and then the coordinates by means of the formulæ:

$$\left.\begin{array}{lll} x_1 = r_1 \cos \alpha & x_2 = b - r_2 \cos \beta & x = \frac{x_1 + x_2}{2} \\ y_1 = r_1 \sin \alpha \sin \delta_1 & y_2 = r_2 \sin \beta \sin \delta_2 & y = \frac{y_1 + y_2}{2} \\ z_1 = r_1 \sin \alpha \cos \delta_1 & z_2 = r_2 \sin \beta \cos \delta_2 & z = \frac{z_1 + z_2}{2} \end{array}\right\} \quad \ldots \ldots \quad (5)$$

If AB be not horizontal, the definitive coordinates X, Y, Z must then be calculated by means of (2).

The shortest distance of the sight-lines and the mean error of z may be calculated as shown in our first paper.

But, generally, if the observations are good, $\delta_1 - \delta_2$ will be so small an angle, that one may put $\sin^2 \frac{\delta_1 - \delta_2}{2} = 0$ and $\cos \frac{\delta_1 - \delta_2}{2} = 1$; thus by (3): $\theta = 180° - (\alpha + \beta)$. Then (4) will reduce to

$$r_1 = \frac{b \sin \beta}{\sin (\alpha + \beta)} \text{ and } r_2 = \frac{b \sin \alpha}{\sin (\alpha + \beta)}$$

and the values of x, y and z given by (5) will be the same as those given by (1), if we put there $\frac{\delta_1 + \delta_2}{2}$ instead of δ. Also the shortest distance Δ will be

$$\Delta = 2 \sin \frac{\delta_1 - \delta_2}{2} \cdot \frac{b \sin \alpha \sin \beta}{\sin(\alpha + \beta)} \quad \ldots \ldots \ldots \ldots \ldots \ldots \quad (6)$$

and thus the mean error of z easily calculated.

The formulæ for calculating the direction and velocity of motion will be the same as those given in our first paper. Instead of numerical work we may use the graphical or mechanical method of solving triangles.

As to the photographic method, this cloud equatorial will also have the advantage, that one may determine on each of the two corresponding photographs a series of corresponding lines, such that every point in a line of the one photograph will have its identical point in the corresponding line of the other. This will facilitate the determination of those points.

These advantages will also be found, if such instruments be used to measure the height and movement of auroras, and as now Dr. M. Brendel, of Berlin, has succeeded in photographing auroras (at Bossekop in Norway last winter) the photographic method will be applicable to them also.

The following, I think, will be a striking illustration to the above named advantage. Suppose the sky be covered with long cirrus stripes (cirro-filum) thin and smooth. Now we may succeed in identifying a stripe; nevertheless, using theodolites, we are unable to identify a point, except that being in the common vertical plane; but using equatorials we generally can, and shall fail only in the exceptional case, when the stripe happens to fall in the common plane of the sight-lines.

Next suppose we wish to determine the altitude, position. and motion of a

beam of aurora, a highly interesting problem, not yet solved. The direction of such a beam, probably being that of the dipping needle, will be nearly vertical, and then we are quite unable to identify a point by using the theodolite, but can easily do so by using the equatorial.

I shall be glad if a competent meteorologist, who has time and money to spend on this question, would carry out this excellent idea of Mons. Lettry.

The meteorologists, to whom I have hitherto recommended it, fear, as it seems, to meet theoretical or practical difficulties in dealing with such a new instrument, difficulties which, however, do not, I think, really exist for any-one acquainted with the methods of practical astronomy.

DISCUSSION.

Rev. W. Clement Ley said that as a cloud measurer of some twenty-five years' experience, he felt very thankful to Dr. Ekholm for the work he had accomplished in the direction of devising means for obtaining accurate and useful cloud observations, and he considered that meteorologists generally had long been indebted to Dr. Ekholm for much valuable assistance in this department of meteorological investigation. He could not pretend to offer any remarks or criticism upon the paper just read, as he had not had an opportunity of studying the paper beforehand. Photography did not appear to be the most successful method of ascertaining the rate of motion of high cirrus clouds, and the plan which he had found to give the best results was to have two observers (with an assistant each if possible) stationed from ten to thirty miles apart, and each provided with a theodolite so that simultaneous measurements of the altitude of high clouds could be obtained, the assistants sketching the isolated cirri during the observations. The altitude of low cumulus clouds could be fairly well determined by calculation from the shadows they cast on the sea, or even by means of the shadow thrown on the land if some patience and time were expended upon it, it being necessary to prepare a plan of the district surrounding the place of observation so that the dimensions of the shadow could be accurately estimated.

RAINFALL OF NOTTINGHAMSHIRE, 1861-90.

BY HENRY MELLISH, F.R.Met.Soc.

[Received November 1st.—Read December 21st, 1892.]

IN the following paper I have attempted to discuss the rainfall of Nottinghamshire during the 30 years 1861-90. It is almost needless to state that nearly the whole of the figures are derived from *British Rainfall* and other publications of Mr. Symons, and I am also indebted to several observers who have been kind enough to furnish further particulars. In addition to the stations actually within the County I have included a considerable number in adjoining Counties, nearly the whole of which are within about 10 miles of the County boundary.

MEAN ANNUAL RAINFALL.

The first point I propose to consider is the mean annual rainfall in different parts of the district. For this purpose the returns have been utilised for all stations for which the record extends over at least 10 years (in a few cases returns of nine years have been used). About 65 stations are available, and the returns have all been reduced to the average of the 30 years 1861-90 by determining the ratio which the mean annual rainfall for the years of observation at each station bore to the mean of the corresponding years out of the 30 years at the nearest station or stations for which the returns were complete for the whole period. Thus the mean rainfall at Hodsock for the 15 years 1876-90 is 25·98 ins.; by calculating the mean ratio of the fall for these 15 years to the fall for the 30 years at Tickhill, Worksop, and Retford, three stations nearly equidistant, for which the returns are complete, and reducing 25·98 ins. in the same proportion, we get 24·54 ins. as the calculated average for the 30 years. Other stations have been treated in a similar way.

In most cases the rain gauge appears to have been kept in the same situation throughout the period, but in a few instances the records of two different gauges kept at different portions of the period have been combined, and in a few others the observer seems to have moved to a different house in the same neighbourhood. Thus the mean adopted for Beeston is formed of 20 years' observations at Highfield House, by Mr. Lowe, and 10 years at Beeston Fields, by Mr. Fellows. Separate records have been combined in a similar way at Derby, Waltham, Thoresby, and perhaps at Branston; while in the case of Nottingham and both records at Belper the observers appear to have moved during the period; at Nottingham more than once. No doubt these combined records are not nearly so satisfactory as an unbroken return from one station, but under the circumstances it seemed the best way of dealing with the observations for this inquiry.

The mean values so obtained were next entered on a map of the district, and lines of equal rainfall were drawn at intervals of 1 inch (Fig. 1). The values are on the whole very fairly consistent, and show a mean rainfall varying from about 30 ins., or rather more at a few places, in Derbyshire in the

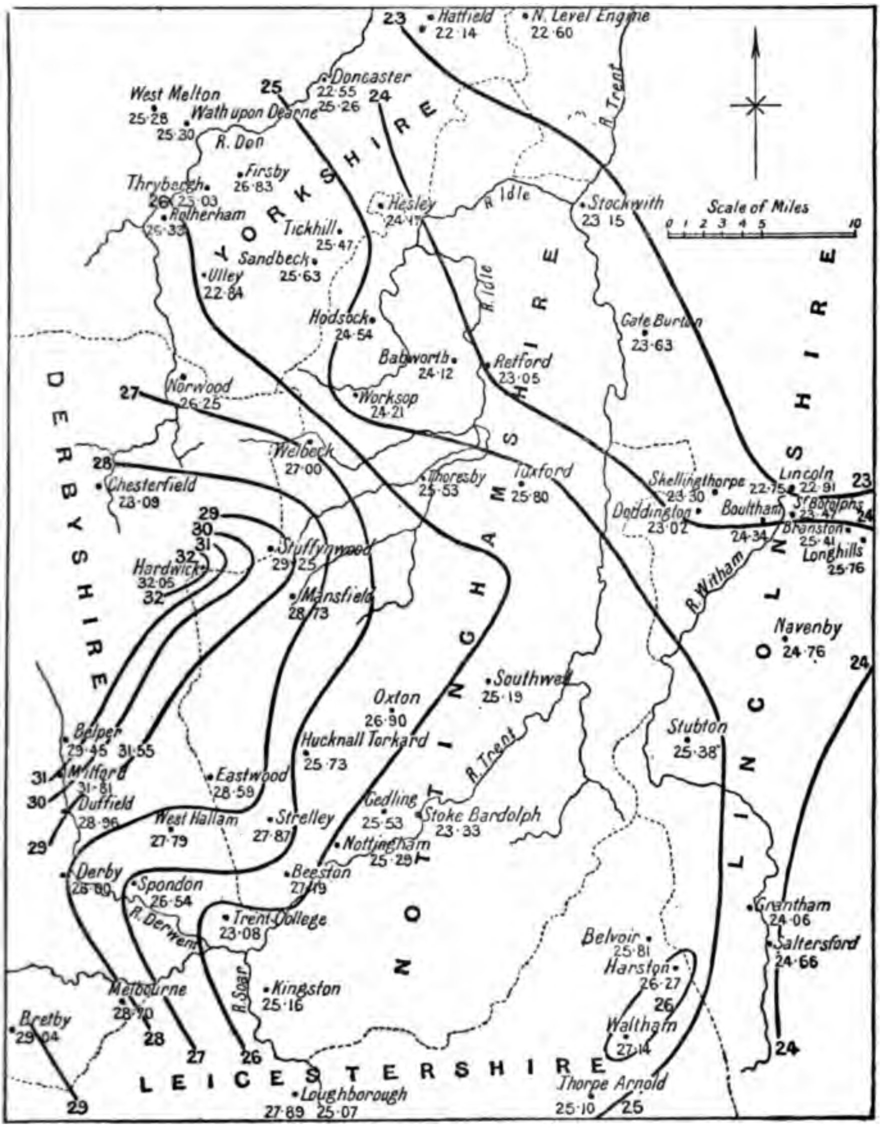

FIG. 1. MEAN ANNUAL RAINFALL.

south-west, to something under 23 ins. in Lincolnshire and Yorkshire in the north-east.

Considering only the Nottinghamshire stations, we find that the area in which the mean rainfall is 27 inches or more is confined to a rather narrow

strip on the extreme west of the County, and extending from Welbeck in the north to Beeston in the south. Over all the rest of the County the rainfall varies between 25 and 27 ins. till we get nearly as far north as the line of the M. S. & L. Ry., which crosses the County from east to west. North of this line the rainfall is less than 25 ins., and in the north-east, towards Gainsborough, apparently not much more than 23 ins.

An accurate knowledge of the local configuration of the ground might very likely remove several of the apparent discrepancies and irregularities, while others are most likely due to differences of situation and exposure of the gauge. Thus at Stoke Bardolph the mean amount is about 2 ins. less than might have been expected from the records of neighbouring stations; but as the gauge is over 6 ft. above the ground, some part of the deficiency is probably due to this cause. The gauges kept by the M. S. & L. Ry. Co. are placed at a height of 3 ft. 6 ins. above the ground, and the returns from them are probably in most instances rather too low in consequence. The effect of height above sea level in increasing the rainfall is well shown throughout, both in the general and in the more local distribution. Thus the larger rainfalls in the west occur in a generally hilly district, while the dry district in the north-east is a flat country at only a small elevation above the sea. Taking more local instances, we see that at Lincoln and in the low ground to the west of the city the fall is generally from 23 to 24 ins., whereas at Branston only a few miles to the south-east, but on rather higher ground, it rises to 25·5 ins. So at Hucknall Torkard in the valley of the Leen the rainfall is only 25·7 ins., while at Strelley on the ridge separating the Leen from the Erewash it is as much as 27·9 ins. Again on the high land south of Belvoir the rainfall is more than 2 ins. greater than down in the valley at Grantham. The lowest mean at any station is 22·14 ins. at Hatfield, to the north-east of Doncaster, at an elevation of about 30 ft. above the sea; the highest is 32·05 ins. at Hardwick between Mansfield and Chesterfield, about 600 ft. above the sea and the highest of all the stations.

Rainfall in each Year.

In order to discuss the rainfall in each year, and its relation to the average, 12 stations have been selected, at which the observations have been continuous throughout the 30 years, and none have been included at which the gauge appears to have been moved during the period. At 3 of them the record for the year 1861 is wanting, at 1 that for 1890; and those 4 values have been completed by interpolation. The following are the stations, the first 7 belonging to the M. S. & L. Ry. Co.:—Worksop, Retford, Lincoln, Gate Burton, Stockwith, Norwood, Chesterfield, Belvoir, Tickhill, Stubton, Oxton, and Wath upon Dearne. For each of these stations the rainfall for each of the 30 years has first been calculated as a percentage of the mean rainfall for the 30 years at that station, taken as 100, and the mean of these for the 12 stations has then been taken and is given in Table I. and also diagrammatically in Fig. 2.

TABLE I.—RATIO OF THE RAINFALL IN EACH YEAR TO THE AVERAGE TAKEN AS 100 (MEAN OF 12 STATIONS).

	Year.	Ratio.	Year.	Ratio.	Year.	Ratio.
	1861	86	1871	97	1881	104
	1862	88	1872	142	1882	135
	1863	79	1873	77	1883	124
	1864	75	1874	73	1884	75
	1865	94	1875	112	1885	102
	1866	108	1876	121	1886	116
	1867	99	1877	118	1887	68
	1868	90	1878	109	1888	92
	1869	103	1879	107	1889	108
	1870	76	1880	138	1890	83
Mean of 10 years		90		109		101

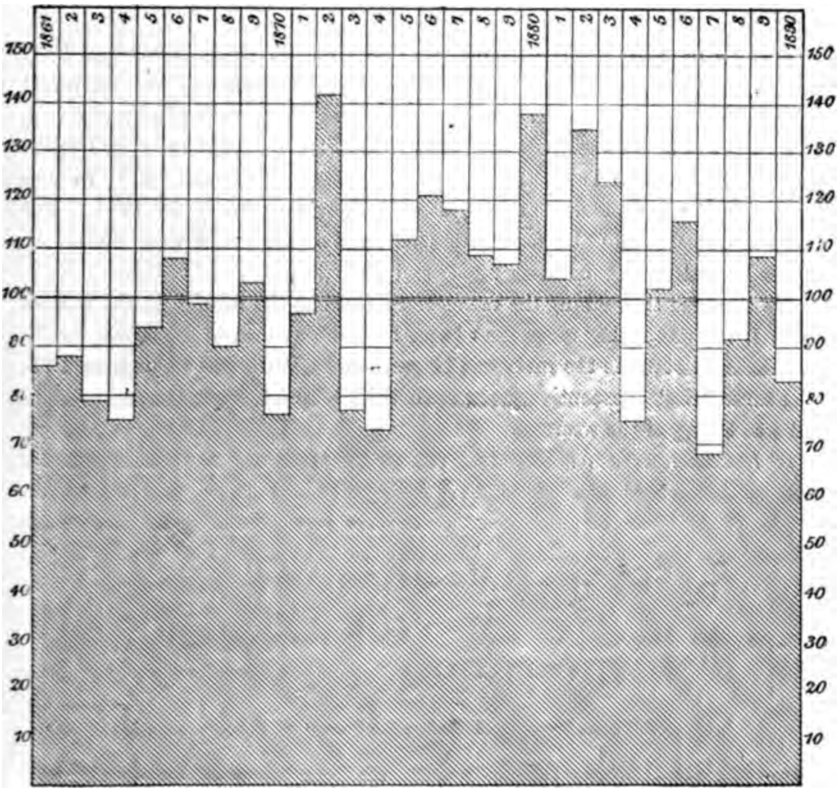

Fig. 2 ANNUAL FLUCTUATION OF RAINFALL.

The last line gives the mean for each of the three decades; and shows that in the first of these the rainfall was 10 % below the average, in the second 9 % above, while in the last it was only 1 % higher than the mean. The two most striking points in the Table are the deficiency of rain during the first 11 years, only two of which were wetter than the average; and secondly

the very large excess during the 9 years 1875 to 1888, the mean for which was 19 % above the average. In each of these 9 years there was an excess in the average rainfall of the whole 12 stations, but in 3 years there was a small deficiency at a few individual stations, chiefly in the north of the district. In *British Rainfall* for 1886 Mr. Symons has shown that the wetness of this period was unique, and that there was nothing approaching to it even back to 1726.

The wettest year of the period was 1872 with 142 %; both 1880 and 1882, however, ran it rather close with 138% and 135% respectively. In fact, at 3 stations, all in the north, 1880 was the wettest year, viz. at Retford, Norwood, and Wath, the excess at the last being 68 %, at three others, Lincoln, Stockwith, and Belvoir, 1882 was wettest, the largest excess being 48·5 % at Stockwith. The remaining 6 stations had their maximum in 1872, 150 % at Worksop being the highest value recorded. Other wet years were 1883 with 124 %, and 1876 with 121 %.

Turning to the opposite extreme, we find that the driest year was 1887 with a deficiency of 32 %. At 8 out of the 12 stations the minimum occurred in this year, the largest deficiency being 39 % at Retford; at Oxton 1863 was the driest year, the deficiency being 34 %; at Belvoir and Wath the minimum was in 1864, the deficiencies being 37 % and 39 % respectively; finally at Lincoln the greatest deficiency was 32 % in 1884. For these three years and also for 1870, 1873, and 1874, the average deficiency at the 12 stations lay between 21 % and 27 %.

We thus see that taking the mean of 12 stations the rainfall in the wettest year, 1872, was rather more than twice as much as that in the driest, 1887; at individual stations the ratio was larger, and at Wath was as high as 2·75. The three driest consecutive years were 1862 to 1864, when the mean rainfall was 81 % of the average.

In *British Rainfall*, 1881, Mr. Symons discussed the annual rainfall at 9 stations distributed over England for each year since 1830, and the corresponding values for the subsequent years have been given in the subsequent annual volumes. The values so obtained for the period now under review are given in Table II.; the average for the 50 years 1830-79 being taken as 100.

TABLE II.—RATIO OF THE RAINFALL IN EACH YEAR TO THE AVERAGE FOR 1830 TO 1879 TAKEN AS 100 (MEAN OF 9 ENGLISH STATIONS)

	Year.	Ratio.	Year.	Ratio.	Year.	Ratio.
	1861	93	1871	96	1881	107
	1862	102	1872	133	1882	124
	1863	93	1873	91	1883	111
	1864	74	1874	90	1884	80
	1865	103	1875	113	1885	102
	1866	113	1876	118	1886	115
	1867	95	1877	117	1887	69
	1868	103	1878	106	1888	97
	1869	106	1879	109	1889	92
	1870	78	1880	119	1890	83
Mean of 10 years		96		109		98

Comparing this with the Table I. given above for Notts and district, we see that the first decade was drier in Notts than in England generally, while the last ten years have been wetter; for the intermediate period the values are about the same. The year 1887 again comes out as the driest and with just about the same value, and a reference to the complete table given in *British Rainfall* for 1881, shows that it was the driest of the whole 61 years. The year 1872 was also the wettest of the 30 years, but the excess was not so large throughout the country as in Notts; moreover it was not quite so wet as 1852.

The average of the above Table is 101, indicating that the mean rainfall for the 30 years now under consideration was 1 °/₀ higher than the mean for the longer period of 50 years 1830-79.

The corresponding values for 1891 were:—For Notts 106, and for the whole of England 110.

Monthly Rainfall.

For the discussion of the distribution of the rainfall throughout the year 10 stations have been taken, at nine of which the record seems to have been continuous throughout, while the tenth is made up of 20 years' observations at Highfield House, Beeston, and 10 years' at Beeston Fields. For the present purpose this combination of two records does not seem open to the same objection as it would have been for discussing the ratio of the rainfall in different years. Table III. gives the average monthly rainfall at each of these stations during the 30 years, as well as the mean of the 10; the last line gives this mean, expressed as a percentage of the total rainfall in the year.

TABLE III.—Mean Monthly Rainfall for the Thirty Years 1861–90.

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
Worksop	1·66	1·62	1·68	1·62	2·06	2·03	2·33	2·33	2·25	2·71	1·97	1·95	24·21
Retford	1·59	1·45	1·58	1·57	2·09	1·87	2·28	2·19	2·16	2·53	1·95	1·79	23·05
Norwood	1·96	1·70	1·87	1·84	2·15	2·10	2·44	2·51	2·36	3·10	2·12	2·10	26·25
Stockwith	1·53	1·37	1·57	1·43	1·90	2·00	2·47	2·32	2·21	2·53	1·98	1·84	23·15
Gate Burton ..	1·65	1·55	1·54	1·55	1·91	2·09	2·35	2·31	2·22	2·56	2·03	1·87	23·63
Lincoln	1·52	1·48	1·43	1·59	1·75	2·00	2·21	2·42	2·21	2·36	2·00	1·78	22·75
Chesterfield	2·37	1·92	2·00	1·90	2·24	2·22	2·31	2·58	2·46	3·43	2·40	2·26	28·09
Belvoir	1·86	1·71	1·77	1·92	2·04	2·03	2·53	2·35	2·50	2·67	2·29	2·14	25·81
Beeston	1·94	1·80	1·89	1·81	2·20	2·28	2·73	2·88	2·59	2·74	2·15	2·17	27·18
Tickhill	1·80	1·60	1·81	1·67	2·03	2·05	2·62	2·38	2·46	2·81	2·16	2·08	25·47
Mean	1·79	1·62	1·71	1·69	2·04	2·07	2·43	2·43	2·34	2·74	2·10	2·00	24·96
Percentage ..	7·2	6·5	6·8	6·8	8·2	8·3	9·7	9·7	9·4	11·0	8·4	8·0	

The result shows a well marked maximum in October, with a secondary one in July and August. In fact at Lincoln and Beeston, August is slightly the wettest month, though at all other stations the maximum is in October. The intervening minimum in September is fairly marked at most stations, while the drop in the curve after October is very rapid. The driest month

is February, though the fall is very slightly larger in both March and April; in fact at two stations the minimum is in March, while at two others April is as dry as February. If a correction were applied for the difference in length of the months, these three months, and also January, would come out very nearly the same, March being slightly the driest.

Fig. 3 gives the mean rainfall in each month.

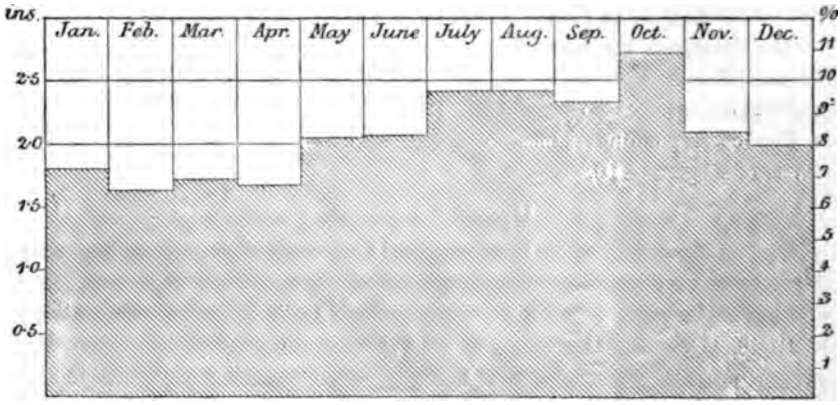

Fig. 3. MEAN MONTHLY RAINFALL

Mr. E. J. Lowe has, in the local press, discussed the rainfall at Beeston during the 50 years 1840-89, the returns from his own observations at Highfield House being used for the first 40 years, and those at Beeston Fields for the last 10 years. The mean fall and the percentage for each month are given in Table IV.

TABLE IV.—MEAN RAINFALL AT BEESTON FOR THE 50 YEARS, 1840–89.

Months.	Fall.	%		Fall.	%
January	1·9	7·1	July	2·6	9·7
February	1·7	6·3	August	2·9	10·8
March..........	1·7	6·3	September	2·6	9·7
April	1·8	6·7	October	2·8	10·5
May	2·2	8·2	November	2·2	8·2
June	2·4	9·0	December	2·0	7·5
			Year	26·8	100·0

Comparing these figures with those for the 30 years we find that they are generally similar; the maximum remains as before in August, while March shares the minimum with February; the rise from the minimum to the maximum has become rather more regular, and the range is somewhat larger, but there is nothing in the figures to show that the 30 years do not give a fairly satisfactory average.

It would be interesting to have compared the monthly distribution in this district with that over the whole country for the same period, but unfortunately the figures are not readily available. The tables published by the

Meteorological Office giving the monthly rainfall at 366 stations for the 15 years 1866-80 do, however, render such a comparison possible for this shorter period. Taking the same ten stations the average percentage for the 15 years was as follows:—

	%		%		%
Jan.	6·8	May	7·5	Sept.	10·4
Feb.	6·6	June	8·6	Oct.	10·4
March	5·8	July	9·7	Nov.	8·1
April	7·0	Aug.	10·1	Dec.	9·0

This curve differs to some extent from that for the 30 years; September is as wet as October, and wetter than either July or August, while the minimum falls in March instead of February. October was the wettest month in the north-western part of the district, and September in the remainder, the two groups on the average just neutralising each other. An examination of the figures for the whole 366 stations shows that during these 15 years the maximum occurred in September over by far the greater part of England; October was the wettest month in portions of the south-eastern counties, on the south shore of the Bristol Channel, in the whole of Wales, and in the greater part of Lancashire, and parts of the West Riding and north Derbyshire (including the stations in our district already referred to); it was also wettest in the north-west of Ireland, and in parts of the Highlands of Scotland. The maximum occurred in January in a narrow strip on the south coast of England, in the south and west of Ireland, in the English Lake district and over a large part of Scotland; it occurred in December in Northumberland, and at a few scattered stations in July, August, and November. Turning next to the minimum we find it as early as February at only a few stations on the Yorkshire coast; it occurred in March over the greater part of England and the east coast of Scotland; in April in a strip running from the Severn to Morecambe Bay; in May over the whole of Ireland, the greater part of Wales and Scotland, the north-west and parts of the south coast of England; and as late as June in the south-west of England. Thus we seem to have both maximum and minimum at about the same time as the greater part of the centre and east of England, while Ireland, Scotland, Wales, and parts of the south coast of England, have both phenomena somewhat later in the season.

In order to examine the wettest and driest months during the period I have taken out the average rainfall at the same ten stations. This average exceeded 5 inches in the following 11 instances, which are arranged in order of wetness.

Month.	Year.	Average Fall. ins.	Month.	Year.	Average Fall. ins.
December	1868	6·20	October	1885	5·42
October	1880	6·07	July	1872	5·22
August	1878	5·95	August	1881	5·14
December	1876	5·67	September	1883	5·09
July	1880	5·56	October	1882	5·01
May	1886	5·52			

In August 1878 the rainfall at Beeston was 8·76 ins. which appears to have been the largest monthly rainfall at any of these stations during the period.

Among the dry months there were the following 12 cases in which the average rainfall did not exceed 0·5 inch.

Month.	Year.	Average Fall. ins.	Month.	Year.	Average Fall. ins.
September	1865	·12	June	1887	·36
December	1873	·15	February	1886	·41
January	1880	·23	June	1868	·41
July	1868	·23	July	1885	·42
July	1869	·28	August	1861	·42
February	1863	·30	November	1889	·50

In the "Jubilee" month, June 1887, the rainfall over the greater part of the district was less than ·25 inch, but a heavier rainfall at Belvoir and Beeston raised the average to the figure given. It will be noticed that the Table includes two consecutive months, June and July, 1868, the aggregate average during which only amounted to 0·64 inch, and at some places was less than 0·5 inch.

Since the close of the period we have had another very dry month, February 1891, which seems to have been about as dry as September, 1865.

Table V. gives the adopted average rainfall and other particulars for each of the stations.

TABLE V.—Average Annual Rainfall, 1861–90.

Stations.	Authorities.	Height above Sea Level.	No. of Complete Years.	Period.	Mean for these years.	Corrected Mean for 30 years.
Nottinghamshire.						
		Ft.			Ins.	Ins.
Kingston Hall	W. English	150?	10	1881–90	24·87	25·16
Beeston, Highfield House	E. J. Lowe	174	20	1861–80	27·34	27·19
Beeston Fields	G. Fellows	206	10	1881–90	26·88	
Nottingham, Arboretum	M. O. Tarbotton	241	24	1867–72	26·38	25·29
" The Park	"	183		1873–87		
" The Castle	A. Brown, C.E.	192		1887–90		
Stoke Bardolph, Sew. Fm.	J. Avis	80	12	1879–90	24·53	23·33
Strelley Hall	T. L. K. Edge	396	11	1880–90	28·61	27·87
Gedling	Lord Forester	137	19	1868, 1870–87	26·88	25·53
Eastwood Colliery	E. Lindley	245	9	1882–90	28·07	28·59
Hucknall Torkard, Forge Mills	J. D. Walker	200?	10	1881–90	25·85	25·73
Oxton	H. Sherbrooke	182	28	1862–89	27·30	26·90
Southwell	Miss Gaster	200	10	1872–81	28·20	25·19
Mansfield, Grove House	R. Tyrer	350	12	1870–81	31·11	28·73
Tuxford	J. N. Dufty	220	9	1880–88	26·65	25·80
Whitemoor House	H. Horncastle	175?	10	1871–80	27 17	25·53
Thoresby Gardens	A. Henderson	175	10	1881–90	26·25	
Welbeck	W. Tillery	180?	15	1861–75	25·15	27·00
Worksop	M. S. & L. Ry. Co.	127	30	1861–90	24 21	24·21
Retford	Do.	52	30	1861–90	23·05	23·05
Babworth Hall	Lt.-Col. Denison	92	19	1872–90	24·87	24·12
Hodsock Priory	H. Mellish	56	15	1876–90	25 98	24·54
Hesley Hall	B. I. Whitaker	61	15	1876–90	25·58	24·17

TABLE V.—Average Annual Rainfall, 1861–90—*Continued.*

Stations.	Authorities.	Height above Sea Level.	No. of Complete Years.	Period.	Mean for these years.	Corrected Mean for 30 years.
		Leicestershire.				
		Ft.			Ins.	Ins.
Thorpe Arnold	Rev. J. S. Swift	336	15	1876–90	26·61	25·10
Loughborough, Cedar Cottage	J. Giles	327	25	1866–90	29·17	27·89
Loughborough, Victoria Street	W. Berridge	169	12	1879–90	25·89	25·07
Waltham Rectory	Rev. G. E. Gillet	560	9	1862–70	23·10	27·14
Waltham le Wolds	E. Ball	536	19	1872–90	29·38	
Harston	J. Beasley	..	20	1870–89	27·37	26·27
Belvoir Castle	W. Ingram	237	30	1861–90	25·81	25·81
		Derbyshire.				
		Ft.			Ins.	Ins.
Bretby Park	G. Blunt	405	25	1866–90	29·95	29·04
Melbourne	Miss Tasker	..	15	1876–90	30·08	28·70
Trent College	C. U. Tripp	120	12	1869–80	25·11	23·08
Derby	J. Davis	180	14	1861–74	26·03	28·00
"	Messrs. J. Davis & Sons	174	4	1887–90		
" Christ Church Vicarage	Rev. W. H. Askwith	265	11	1876–86	31·86	
Spondon	J. T. Barber	272	13	1872–83, 1885	30·63	26·54
West Hallam	Rev. C. J. Newdigate	356	11	1865–75	28·13	27·79
Duffield	W. Bland	250	23	1867–89	30·32	28·96
Milford	B. Cooper	210?	10	1875–84	37·71	31·81
Belper	J. G. Jackson	222	16	1866–75	32·14	29·45
" Fernslope	"	353		1876–81		
" Field Head House	J. Hunter	355	14	1877–82	33·07	31·55
" Northfield	"	225		1882–90		
Stuffynwood Hall	J. Paget	389	14	1876,77, 79–90	29·90	29·25
Hardwick Hall	Mr. Wilson	594	15	1876–90	32·83	32·05
Chesterfield	M. S. & L. Ry. Co.	248	30	1861–90	28·09	28·09
Norwood	"	258	30	1861–90	26·25	26·25
		Lincolnshire.				
		Ft.			Ins.	Ins.
Saltersford	H. Preston	188	9	1882–90	25·31	24·66
Grantham	J. W. Jeans	179	20	1861–80	23·70	24·06
Stubton	G. Nevill	94	29	1862–90	25·50	25·38
Navenby	Rev. J. Hays	216	22	1869–90	25·84	24·76
Branston Hall	A. S. Leslie Melville	136	20	1866–76, 1878–80, 1885–90	25·76	25·41
Longhills	"	110?	13	1872–84	29·26	25·76
Boultham	F. Terrill	18	16	1875–90	26·65	24·34
St. Botolphs	H. Teague	25	15	1876–90	25·65	23·47
Doddington	Rev. R. E. Cole	92	15	1876–90	25·16	23·02
Lincoln	M. S. & L. Ry. Co.	26	30	1861–90	22·75	22·75
" The Quarry	R. Swan	186	12	1879–90	24·26	22·91
Skellingthorpe Hall	R. C. B. Coupland	..	14	1877–90	25·10	23·30
Gate Burton	M. S. & L. Ry. Co.	96	30	1861–90	23·63	23·63
Stockwith	"	21	30	1861–90	23·15	23·15
Thorne, North Level Engine	A. L. Peace	12?	10	1881–90	22·90	22·60

TABLE V.—AVERAGE ANNUAL RAINFALL, 1861–90—*Continued*.

Stations.	Authorities.	Height above Sea Level.	No. of Complete Years.	Period.	Mean for these years.	Corrected Mean for 30 years.
		Yorkshire.				
		Ft.			Ins.	Ins.
Ulley Reservoir	L. Berry	184	16	1875–90	24·42	22·84
Sandbeck Park	G. Summers	150	14	1877–90	26·96	25·63
Rotherham, Moorgate Grove	R. Chrimes	262	26	1865–90	27·03	26·33
Thrybergh	W. H. Crabtree	184	12	1879–90	24·39	23·03
Tickhill	Dr. Dixon / G. C. Phillips	61	30	1861–90	25·47	25·47
Firsby	W. H. Crabtree	189	11	1880–90	28·30	26·83
Wath-upon-Dearne	Dr. Burman	185	29	1862–90	25·38	25·30
West Melton / ,,	Rev. J. Boyd / W. Jackson	172	26	1862–65 / 1868–70 / 1872–90	25·48	25·28
Doncaster	M. S. & L. Ry. Co.	35	23	1868–90	23·49	22·55
,, Magdalens	J. Howorth	46	27	1864–90	25·80	25·26
Hatfield	T. Askren	30?	10	1881–90	21·64	22·14

DISCUSSION.

Mr. SYMONS expressed his satisfaction at the excellent manner in which the paper had been compiled. It was a debatable question, and was in fact quite a matter of policy, whether it might not have been an improvement to have applied some correction for variations in the heights of the rain gauges above the ground, and also for elevation above sea level. There were certain of the stations organised by the M. S. & L. R. Co., of which he was disposed to be rather suspicious, and some of the results in this paper appeared to support this view. During recent years, however, one of the directors had exhibited a strong interest in the observations carried on by his Company, the stations had been inspected by one of the Company's officers, and there was every probability that the rainfall from these stations was now more reliable.

Mr. SOUTHALL remarked that in addition to the effect of the height of the rain gauge above the ground and above the sea level upon the rainfall, the question of the contiguity of hills also required to be considered when studying rainfall. In many points the correspondence of the distribution of the rainfall over Herefordshire with that over Nottinghamshire was very remarkable.

Mr. WALLIS said, that while endorsing the opinion of the previous speakers as to the very complete manner in which the records were worked up, he could not refrain from criticising the unnumbered Table following Table IV. Fifteen years was much too short a period to show the relative wetness of the different months of the year, and even 30 years was not long enough for absolute certainty, as was shown by the fact that Mr. Mellish's 30 years gave October as the wettest month, while Mr. E. J. Lowe's 50 years at Beeston gave August as the wettest.

Mr. TRIPP said that so far as he understood the paper different periods of years appeared to have been used in determining the ratios between records differing in length. It was interesting to note how widely spread the excess of rain was in 1872, all the European stations on the Atlantic seaboard having falls exceeding the average, while in Central Africa, according to the accounts of Mr. H. M. Stanley, who was then returning to the west coast after discovering Livingstone, extensive floods prevailed. In Cape Colony, too, the excess was more universal than that of any other year, so that it appeared probable that the excessive rainfall extended from the north of Europe to the south of Africa. In 1887, the year of excessive drought, the deficiency in rainfall extended to the south of

Europe, and was present in the eastern province of Cape Colony, but in other parts of the world, Australia, central Asia, and parts of India, the year was a very wet one.

Mr. MELLISH, in reply, said that the method which he had adopted for ascertaining the ratio between the mean rainfall at a station with a period of 15 years, and at another with a period of 30 years, was to calculate the ratio of the two averages and apply a suitable correction to the average of the shorter period to make it comparable with that for the longer period. He thought it was desirable to apply a correction for differences in the elevation of rain gauges above the ground, but did not quite know what allowance to make. He considered that it was very doubtful if any advantage would result from applying a correction for height above mean sea level, as the rainfall so corrected would not be truly representative of the district, especially in the case of a very hilly country.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

November 16th, 1892.

Ordinary Meeting.

ARTHUR BREWIN, Vice-President, in the Chair.

EDGAR TARRY ADAMS, The Cottage, Halstead, Essex;
ARTHUR LLOYD JONES, M.R.C.S., Rotherslade, Langland Bay, Swansea;
JAMES E. PRINCE, 1 Henry Street, Windsor, Melbourne; and
WILLIAM TATTERSALL, 90 Arden Terrace, Accrington,
were balloted for and duly elected Fellows of the Society.

The following Papers were read:—

"THUNDERSTORM, CLOUDBURST, AND FLOOD, AT LANGTOFT, EAST YORKSHIRE, JULY 3rd, 1892." By JOHN LOVEL, F.R.Met.Soc. (p. 1.)

"ON THE MEASUREMENT OF THE MAXIMUM WIND PRESSURE, AND DESCRIPTION OF A NEW INSTRUMENT FOR INDICATING AND RECORDING THE MAXIMUM." By W. H. DINES, B.A., F.R.Met.Soc. (p. 16.)

The Meeting was closed at 8.45 p.m., when a Special General Meeting was held to consider certain alterations in the By-Laws recommended by the Council, which were adopted by the Meeting.

December 21st, 1892.

Ordinary Meeting.

C. THEODORE WILLIAMS, M.A., M.D., President, in the Chair.

RICHARD HENRY BEARDSLEY, L.R.C.P., The Esplanade, Grange-over-Sands;
THOMAS CARLYLE BEATTY, F.R.C.S., Beulah Hill, Norwood;
RICHARD BROCKLESBY, L.R.C.P., 229 Cleethorpe Road, Great Grimsby;
CHARLES HARINGTON COTTON, Dalbury, Knyveton Road, Bournemouth;
PETER FRASER, M.D., B.Sc., Llangefni, Angelsey; and
GEORGE HERBERT WARD-HUMPHREYS, M.R.C.S., Oriel Lodge, Cheltenham,
were balloted for and duly elected Fellows of the Society.

Mr. J. S. Harding and Mr. H. S. Wallis were appointed Auditors of the Society's Accounts.

The following Papers were read :—

"Moving Anticyclones in the Southern Hemisphere." By H. C. Russell, B.A., F.R.S., F.R.Met.Soc. (p. 23.)

"The Tracks of Ocean Wind Systems in transit over Australia." By Capt. M. W. C. Hepworth, F.R.Met.Soc. (p. 34.)

"A New Instrument for Cloud Measurements." By Dr. Nils Ekholm, Hon. Mem. R.Met.Soc. (p. 38.)

"Rainfall of Nottinghamshire, 1861-90." By Henry Mellish, F.R.Met.Soc. (p. 46.)

CORRESPONDENCE AND NOTES.

Whirlwind on the North Coast of Mayo, September 27th, 1892.—On Tuesday afternoon, September 27th, I was on the Long Car between Sligo and Ballina, from 4 p.m. to 8.30 p.m. We had a strong North-west breeze and occasional showers, some of them with hail. I noticed about 6 p.m. a well-marked "pocky" cloud, using Dr. Clouston's nomenclature for that form of pendulous *cumulus*. This is always an accompaniment of squally weather.

On arrival at Belmullet, on the 28th, I learned from Mr. J. R. O'Brien, the Secretary to the Congested Districts Board, that the Members of that Board had experienced a slight whirlwind close to Benwee Head at about the time when I had seen the pocky cloud; I asked Mr. O'Brien to obtain particulars for me, and I have received from him the subjoined letter from the Rev. W. S. Green, one of the Commissioners, who was a witness of the occurrence.—Robert H. Scott, F.R.S.

"My dear O'Brien,

"I regret not having got the particulars about the whirlwind which chucked the measuring tape out of Beamish's hand ere this, but I several times asked him to weigh it and it was always forgotten.

"The tape was 66 feet long, and when reeled up in its case weighed in all 1 lb. The case weighed about half of this.

"Most of the tape was out, a man holding the end and Beamish the case when the squall came and striking the tape carried the case up in the air, and after sustaining its weight for a few seconds, let it drop in the sea about 100 feet from where it started. We were standing on the shore beneath a hill at Portacloy, near Benwee Head, over which the squalls came, as one generally sees on the lee side of a headland when a gale is blowing. We were struck by one this year under the cliffs of Achill when steaming close under this shelter. We saw it coming, tearing up the sea in its course, and when it struck the *Fingal* she heeled over and the lifeboat was lifted by the sheer force of the wind out of the chocks, and landed on the top of the engine room close by. The force of the blast was quite momentary.—Yours truly, W. S. Green, Congested Districts Board, November 8th, 1892."

Waterspout on Lake Erie.—The following graphic account of a Waterspout observed on Lake Erie in 1842 is taken from a newspaper cutting pasted in an old volume of extracts, &c., which formerly belonged to the Meteorological Society of Great Britain, and which has recently been presented to the Royal Meteorological Society by Mr. G. J. Symons, F.R.S. :—

"On Friday evening last, between five and six o'clock, our citizens enjoyed a

rare and imposing exhibition in the natural world, commonly known as a 'waterspout,' which passed in front of the town within a mile of the beacon light. On Friday the wind blew strong from the North-east, until about five o'clock, p.m., when it changed suddenly to West, still blowing a gale and bringing onward a dark and threatening storm. A few minutes before the change of wind the whirl which caused the spout came off the land two miles west of the pier, producing a great agitation of the water, raising and driving about the spray with great fury, the sea running high at the time. In a short time a portion of the low black cloud which lay directly over the troubled portion of the water descended in the form of a sack half-way to the surface of the lake. It was apparently of the size of a large haystack, hollow, and the spray or vapour of which it was composed had a spiral and upward motion around the cavity of the column. It proceeded from the shore in a north-easterly direction, not in a regular track, but with constant and sudden deviations, perhaps two miles, the portion descending from the clouds at times almost dispersed the strength of the gale. When opposite the harbour its direction became more southerly, its colour changed from the dark cast of a heavy cloud to the whiteness of spray of falling rain, and it took the form of an inverted cone with regular elements, its vortex resting on the water (not larger than a hogshead), its base surrounded by moving clouds. Very little rain fell while it was in sight, and whether this proceeded from the water elevated by the whirlwind could not be ascertained. As it travelled eastward before the wind it approached the shore a mile east of the city, changing shape continually, and causing as it passed a great commotion in the already agitated waters. Here a fresh gust seemed to break up the column and it vanished. Fortunately no boats or vessels were in its route, or damage might have ensued. Among the numerous displays of the grandeur of storms which our waters afford, we have witnessed none more varied or sublime than this. It was not considered a large spout when compared with those which occur on the broad ocean, to the wonder and alarm of the mariner, but seems to have been perfectly formed, though upon a limited scale.—*Cleveland Herald.*

Low Temperatures in the Tweed Valley.—It will no doubt be remembered that intense cold prevailed over the south of Scotland during the severe frosts of December 1879 and January 1881; and that Mr. Marriott quoted the low temperature of —23° as having been registered at Blackadder, in Berwickshire, on December 4th, 1879. Some of the Fellows at that time doubted the accuracy of this reading.

Intense cold prevailed over the same district on February 19th, 1892, when a temperature of —15° was registered at Sunnyside, Jedburgh. The following note on this reading by Mr. G. Hilson is interesting, and it also tends to support the low temperature at Blackadder quoted above:—

"The minimum thermometer (Adie and Sons, Edinburgh) is placed in a louvre boarded box 21 ins. high, 15½ ins. broad, 9¼ ins. wide, painted white and covered on top with zinc, open at the bottom and supported on an iron rod fastened to a stone sunk in the ground on the edge of a grass plot, faces the north and is six yards from the wall of the house. There is a beech tree in front, the bole of which is about ten yards from the stand.

"The thermometer is one that has been in use for many years, and was compared with the Kew Standard and has never been known to be in fault. The scale on it is marked from —10° to 120°. At the minimum end there is on the scale an unmarked space of 5°, and between this and the bend of the glass to the bulb there is a space of 5°. On the morning of February 19th, the minimum end of the indicator was pressed so far down as to bend it at the turn, and the maximum end clearly revealed the —15°.

"This low temperature was surprising, and before touching, the thermometer was watched, a particular note of the position was taken and jotted at once in the register. The thermometer on the previous morning showed 10°, and on the following morning 27°.

"The thermometer will hang about 338 feet above sea-level, and the bed of the water of Jed, distant about a gunshot, will be about 100 feet lower.

"At Ancrum bridge, a place on the south side of the river Teviot, about two miles distant from this, as the crow flies, where careful observations are taken by competent parties with Kew-tested instruments, on the same day the tempera-

ture was —10°, a little further down the river on the north bank at two places it was —5°, differences which to me are obvious from the situations of the places."

Diurnal Barometric Curves.—Dr. Buchan, who made an examination of the diurnal barometric curves at Gries and Klagenfurt in the Tyrol, and at Cordova in the Argentine Republic, found that in deep valleys atmospheric pressure stands much higher during the night and falls much lower during the day than is elsewhere the case. The amounts increase in proportion to the daily range of temperature : or, strictly speaking, to the amounts the temperature falls below the daily mean during the night, and rises above it during the day. Dr. Buchan now finds that the same rule holds in comparatively shallow valleys such as that of the Thames. He has examined Mr. Bayard's paper, "The Diurnal Range of the Barometer in Great Britain and Ireland,"[1] in which the diurnal range is given to ten-thousandths of an inch, and has compared the results from the Greenwich and Kew Observatories, which are only 7 miles apart.

The following are the departures from the daily means at Greenwich and Kew for June from 7 a.m. to noon, in ten-thousandths of an inch:—

	Greenwich.	Kew.	Difference.
7 a.m	+59	+79	20
8 "	+85	+99	14
9 "	+87	+87	0
10 "	+91	+67	—24
11 "	+67	+45	—22
Noon	+17	— 7	—24

It is evident that the ordinary diurnal barometrical curve at Kew has superimposed on it a strongly marked curve, due to the relatively low position of the observatory in the valley of the Thames.

Meteorological Observations at Accra and Aburi on the Gold Coast.—The Secretary of State for the Colonies has forwarded to the Society diagrams prepared from the meteorological observations made at Accra and Aburi by Dr. Easmon, Assistant Colonial Surgeon of the Gold Coast Colony. The charts, which comprise temperature, rainfall, and humidity, are reproduced on Plate V. The information received shows that the instruments were of good quality, and that they were well exposed.

Currents of the North Atlantic.—At the Meeting of the British Association in August 1892, H.S.H. Albert Prince of Monaco exhibited and described a new Chart of the Currents of the North Atlantic, which was based upon several series of experiments upon the superficial currents which he had made in his sailing yacht *Hirondelle* during the years 1885-87. Some 1,600 or 1,700 floats were launched at intervals along certain lines in the Atlantic. The floats, which were of three different types, viz. wooden casks, copper globes, and glass bottles, were all weighted in a manner to prevent any part of their bulk emerging from the water and catching the wind. Each float contained a document printed in nine languages, which requested the person who might find the float to deliver it into the hands of the nearest maritime authorities, to be sent to the Prince of Monaco with detailed indications of the place and date of finding it. Of the floats sent back, it was found that they were distributed on the coasts washed by the Atlantic as follows :—

Azores	37	British Islands	29	Central America	1
Madeira	6	France (West)	36	Bermuda	4
Canaries	21	Spain (North)	14	Open sea	3
Ireland	3	Africa (West)	7	Various	5
Norway	22	Antilles	23		

The stranding of floats successively on the Azores, on the coasts of Europe, Africa, Central America, the West Indies, and Bermuda in the course of a normal period ; then the repetition of this same circuit, indicated by the four

[1] *Quarterly Journal*, Vol. XV. p. 146.

floats recovered in 1891 (two on the coast of France, after being afloat for 4 years 3 months, and 5 years 3 months respectively ; and two on Madeira, after a voyage of 3 years 11 months, and 4 years 2 months respectively) has enabled the Prince of Monaco to establish the fact that the cycle, described by the objects drawn into the vortex of the waters of the North Atlantic, is renewed indefinitely, except in the case where they escape by an offshoot into the Arctic regions along the coasts of Ireland, Scotland, and Scandinavia. This conclusion is arrived at by comparing the dates of the launch and recovery of these four floats, and applying to them the mean velocities deduced from the courses of the earlier floats.

The mean velocity for the region comprised between the Azores, Ireland, and Norway is 3·97 nautical miles in twenty-four hours ; between the Azores, France, Portugal, and the Canaries it is 5·18 nautical miles in twenty-four hours. From the Canaries to the West Indies, the Bahamas, and even to Bermuda, it attains 10·11 nautical miles in twenty-four hours. In the eastern portion of the arc which extends from Bermuda to the Azores, it falls again to 6·42 nautical miles in twenty-four hours. The mean velocity which the combined results give for the North Atlantic is 4·48 nautical miles in twenty-four hours.

The circulation appears to be more active on the western half-circle of the vortex than on the eastern one ; and this is explained by the combined action of various causes, as the Trade Winds, the Equatorial currents, and the Gulf Stream, also the powerful evaporation which in the Tropics stimulates the circulation of the waters, as by the increase of density it always tends to re-establish equilibrium. It would now be of great importance to renew these experiments at different seasons.

Fog Signals.—Dr. H. Mohn has made some experiments on this subject, which were carried out in the Christiania fiord at the Island of Färdo, where there are two sirens. The island can be approached on all sides, so that the audibility of the signals could be tested in all directions as regards the wind. The particular points which Prof. Mohn made out were that the sound suffered reflection off the surface of the sea, and was not, as Prof. Tyndall seems to have imagined, reflected by a vertical wall of cloud. The sound waves go out in spheres, and consequently at times when the sound was inaudible on deck, it was audible at the masthead. The general conclusions were :—The signals are audible at a greater distance aloft than on deck. In cold weather the sounds do not travel so far as in warm. As a rule the sounds are audible to leeward farther than athwart the wind, and athwart the wind farther than to windward. The stronger the wind, the greater is the difference between the audibilities to leeward and to windward. In the same direction the audibility may vary suddenly and greatly. The higher is the elevation of the siren the further will the sound be heard.

Prof. Mohn carried out careful meteorological observations on board his steamer and at the lighthouse during the progress of the experiments, so as to see what influence temperature, pressure, or humidity had on the transmission of the sound.

Comparison between the Evaporation from a surface of Water and a surface of Moist Earth.—We reproduce from *Ciel et Terre* for November 16th, 1892, the following abstract of some experiments made by M. A. Batelli at Chieri, near Turin, in an open field. When the air temperature rises the evaporation from damp earth is in general greater than that from the surface of water at rest, and on the contrary it is less when the temperature falls. The evaporation from a free water surface increases more rapidly with wind velocity than that from damp earth. The greater the relative humidity the greater is the excess of the rate of evaporation from damp earth above that from water at rest, all other conditions being unchanged. The evaporation in sunshine is greater than in shade, not only during the day but also during the succeeding night. When the temperature rises the ratio between the quantities of water evaporated from the two surfaces rises slightly more quickly. When the wind velocity increases, on the contrary, the ratio decreases.

Cotton Fibres and Atmospheric Changes.—Mr. F. E. Saunders, in a note in the Bulletin of the New England Weather Service for September 1892, draws attention to this subject, and says :—

"It is a well known fact that the temperature has quite an important bearing upon cotton fibres during the manipulation from the bale to the cloth room. This must be evident to the most casual observer when we consider the fact that cotton is grown in a warm climate surrounded by a mean temperature of 70°, and then transmitted to a climate that is subject to sudden atmospheric changes, many of them being of low temperature and with an atmosphere divested of moisture.

"Cotton fibres are very susceptible to any atmospheric change; that is to say, they will take on or throw off dampness very readily, consequently any material change of temperature and humidity will affect the successful working of the fibre. In order for cotton to work well in the first processes of manipulating, the dry bulb thermometer of the common psychrometer should stand at 78° and the wet bulb at 66°, which would make the dew point 58° and the relative humidity 52 per cent. This would give 5·371 grains of water vapour per cubic foot of air. Cotton fibres, with this condition of atmosphere, will very readily assimilate and draw even. During very many of the atmospheric changes that are constantly taking place it is found quite impossible to hold the cotton fibres well in hand. This is more noticeable when dry atmosphere prevails with a dry West-northwest wind blowing for twenty-four or thirty-six hours. It is frequently the case where these changes take place that the amount of water vapour in a cubic foot of air will drop as low as 4·290 grains. When these conditions occur the electrical currents of air seriously interfere with the workings of cotton fibres. Electricity causes the fibres to separate, and much more waste is made. Very many of the cotton mills in New England are not supplied with moistened apparatus."[1]

Rainfall at Basle 1755-1888.—Dr. A Riggenbach, in his paper "Die Niederschlags-Verhältnisse von Basel,"[2] has taken all the records available for Basle, which go back to the year 1755. There are, however, interruptions, and accurate measurements of quantity of rain exist only for a brief modern period. The entries of occurrence of rain and of thunderstorms are very complete and of long continuance. Dr. Riggenbach has discussed all the data on the principle of the theory of probabilities, in order to see if any safe conclusion as to coming weather could be drawn from past experience. His results in every case are negative, *e.g.* it is impossible to say whether a wet June indicates a wet July, or *vice versâ*. It is impossible to judge of the duration of snowy weather from the date of appearance of first snow, it is quite possible that later snow in spring may follow thereupon. One result is interesting; the probable duration of dry weather is greater in winter than in summer, and that of wet weather is greater in summer than in winter. It must, however, be remembered that Basle has its rain maximum in June, not in October as London has.

Snow Line.—Dr. Klengel, in his thesis "Die historische Entwickelung des Begriffs der Schneegrenze,"[3] has made a careful analysis of all that has appeared on the subject of the snow line up to the date of A. von Humboldt's paper in the *Annales de Chimie et Physique* for 1820. The subject has mainly a historical interest up to Humboldt's time, but he recognised the fact of the great difference in snow level between the two sides of the Himalayas, an observation which has been since corroborated in other districts. The only region in which snow really reaches sea level, and remains there all the year, is in the Antarctic Zone, as in the South Georgian Islands. In all parts of the Arctic Zone, even in Franz Joseph Land, the snow lies where it is protected from wind, but on exposed land it is removed partly by wind and partly by sun, and vegetation of some sort appears. It used to be formerly believed that all Siberia was covered with snow, but it now is well known that potatoes and wheat are grown at Jakutsk, with a mean annual temperature of 12° F., so that the snow line must lie much above that district.

1 The use of Hygrometers to indicate condition of atmosphere in Spinning Mills was rendered compulsory in this country by the Cotton Cloth Factories' Act, 1889.

2 *Denkschrifte der Schweizerischen naturforschenden Gesellschaft*, Band, XXXII, No. 2.

3 *Verein für Erdkunde*, Leipzig.

RECENT PUBLICATIONS.

American Meteorological Journal. A Monthly Review of Meteorology. October-December 1892. Vol. IX. Nos. 6-9. 8vo.

The principal articles are:—A meteorological balloon ascent at Berlin, October 24, 1891: by A. L. Rotch (7 pp.). The most important result of the ascent was furnished by the comparison between the aspiration and sling psychrometers. The air temperatures obtained by the latter instrument, with rather intense radiation, were always higher than those given by the aspiration psychrometer, the difference averaging about 2°C, and varying from 0°·3C, with feeble radiation, to 3°C. The relative humidities obtained by the aspiration psychrometer were generally from 0 to 9 per cent. above those with the sling psychrometer, the wet bulb of the former being less depressed with respect to the dry bulb than was the wet bulb of the latter instrument. These results seem to show that the sling psychrometer, as used in a balloon, where it cannot be swung far away from the car, and under intense insolation, gives values which are not only too high, but which do not follow the constantly changing temperature and humidity of the air.—Improvement of Weather Forecasts: by Prof. H. A. Hazen (8 pp.).—The Storms of India: by S. M. Ballou (16 pp.).—The Ether and its relation to the Aurora: by E. A. Beals (4 pp.).—Warm and Cold Seasons: by H. Gawthrop (4 pp.).—The facts about rain making: by G. E. Curtis (4 pp.).—Convectional Whirls: by Prof. H. A. Hazen (3 pp.).—Wind measurement: by W. H. Dines (7 pp.).—The first aerial voyage across the English Channel: by R. de C. Ward (5 pp.). This was accomplished by Dr. Jeffries and Mons. Blanchard from Dover to Guines, near Ardres, on January 7th, 1785.—Atmospheric Electricity, Earth Currents, and Terrestrial Magnetism: by Prof. Cleveland Abbe (8 pp.).—Notes on the use of automatic Rain Gauges: by J. E. Codman (5 pp).—Sunshine Recorders: by Prof. C. F. Marvin (4 pp.).—Late investigations of Thunderstorms in Wisconsin: by W. L. Moore (6 pp.).—Observations on the Aurora of July 16th, 1892, at Utica, N. Y.: by T. W. Harris (3 pp.).—Temperature Sequences: by Prof. H. A. Hazen (2 pp.).

Annuaire de la Société Météorologique de France. Tome XL. January-June 1892. 4to.

The principal articles are:—Sur la définition de quelques nouveaux termes employés dans les études de météorologie dynamique: par L. Teisserenc de Bort (5 pp.). This paper deals with the definition and the origins of the barometric gradient.—Resumé des observations centralisées par le Service hydrométrique du bassin de la Seine pendant l'année 1890: par M. Babinet (24 pp.).—Résumé des observations pluviométriques et hydrométriques de 1881 à 1890 (8 pp.).—Différence de température entre stations voisines: par E. Renou (2 pp.)—Sur la hauteur des nuages: par M. Tardy (3 pp.).—Note sur la tempête du 11 Novembre 1891: par G. Guilbert (3 pp.).

Indian Meteorological Memoirs: being occasional Discussions and Compilations of Meteorological Data relating to India and the neighbouring Countries. Vol. V. Part 1. 1892. 4to. 60 pp. and 12 plates.

Contains: The diurnal variation of atmospheric conditions in India: being a discussion of the hourly observations recorded at twenty-five stations since 1873: by Mr. H. F. Blanford, F.R.S. The author in this Part discusses the results from two stations only, viz. Sibsagar, in Upper Assam, and Goalpara, in Lower Assam. The results from the other stations will be published in subsequent Parts.

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. September-October 1892. 4to.

The principal articles are:—Zur Thermodynamik der Atmosphäre: von Dr. W. von Bezold (16 pp.). This is the fourth of these papers, and its subject is super-saturation, sudden cooling, and the generation of thunderstorms. Dr. von Bezold reasons at some length on the action, firstly on the super-saturation of the air with

moisture, and secondly, of the influence of the sudden conversion of this water into ice, on the pressure of the atmosphere, and shows how the peculiar unsteadiness of the barometer in severe thunderstorms may be attributed to these actions. The paper concludes with an explanation of the origin and phenomena of thunderstorms in Germany.—Ueber den klimatischen Wärmewerth der Sonnenstrahlen und über die zum thermischen Aufbau der Klimatie mitwirkenden Ursachen: von Dr. W. Zenker (22 pp.). This is a paper extending over two numbers of the Zeitschrift, in which the author endeavours to show how the various climates of the world are dependent upon the amount of heat from the sun that each district receives or can possibly receive. Most of his data are taken from Wild's work on the temperature of the Russian Empire.—Klima des Puy de Dome in Central Frankreich: von Dr. A. Woeikof (20 pp.). This is a discussion of the observations at the Puy de Dome and at Clermont Ferrand, the two stations differing in elevation about 3,500 ft. Some attempt at local forecasting is made, for daily on the receipt of the telegram from Paris at 1 p.m. a forecast is prepared at the observatory, and posted up in various places in Clermont. Dr. Woeikof discusses the observations in great detail for the twelve years 1878-1889.

Scottish Geographical Magazine. October 1892. Vol. VIII. No. 10. 8vo.

This contains two papers by H.S.H. Albert Prince of Monaco:—1. "A new Chart of the Currents of the North Atlantic" (see p. 60); and 2. "Meteorological Observatories in the Atlantic Ocean." The author recommends that meteorological stations be established at Bermuda; the Azores, with an observatory at the sea-level at Fayal, and one on the summit of the mountain Pico, in the neighbouring island; the island of Madeira; the Canaries (Tenerife); and one on the Cape Verdes, with an auxiliary station on Fogo summit. He suggests that the observations at these places should be telegraphed to Europe and utilised for weather forecasting.

Symons's Monthly Meteorological Magazine. Nos. 321-323. October-December 1892. 8vo.

The principal articles are:—On the Production of Rain: by Cleveland Abbe (10 pp.).—The Rainfall of Jamaica (2 pp.).—The Rainfall of New Zealand (5 pp.).—October Rain and Floods (4 pp.).—Forgotten Meteorological Observations (6 pp.). Mr. Symons recently purchased an old volume, formerly belonging to the Meteorological Society of Great Britian, containing a number of newspaper cuttings and meteorological tables received between 1837 and 1843. In this article he reproduces some of the data given in this old book. The volume has since been presented to the Royal Meteorological Society.—Modern Thermometry (3 pp.).

U. S. Department of Agriculture, Weather Bureau. Bulletin No. 5. 1892. 8vo. 75 pp. and 6 plates.

This Bulletin is devoted to an interesting account of observations and experiments on the fluctuations in the level and rate of movement of ground-water made at the Wisconsin Agricultural Experimental Station farm, and at Whitewater, Wisconsin: by Prof. F. H. King. The author gives a full description with illustrations of the various instruments used, including an air barometer and a self-recording soil thermometer. It appears to be a general rule that the long period barometric oscillations, and perhaps all barometric changes as well, exert a greater influence upon the water of the deeper than upon the shallower wells; because the deeper wells are less affected by local percolation into them.

QUARTERLY JOURNAL

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THE HIGH ALTITUDES OF COLORADO & THEIR CLIMATES.

An Address delivered to the Royal Meteorological Society, January 18th, 1893.

BY C. THEODORE WILLIAMS, M.A., M.D., F.R.C.P.

PRESIDENT.

(Plate VI.)

I HAVE chosen as the subject of my Address to-night, the high altitudes of Colorado and their climates, because the climates of high altitudes have not been prominently brought before the notice of this Society, but it is a subject which is exciting great and increasing interest in the medical profession and among the public, and the influence for good or for evil of these climates on human beings is undoubted. The topic has been partially discussed by Dr. Tucker Wise and myself in this Society, and by others in the Medical Societies, in reference to the Swiss Alps, but, as far as I can remember, no other mountain group has been treated of here, though the works of

Archibald Smith, Denison, and Kellet have given some valuable contributions elsewhere with regard to certain mountain ranges.

It has fallen to my lot to study the effects of elevated regions on hundreds of pulmonary invalids during the last 25 years, and such study has resulted in the formation of very decided conclusions, which now guide my practice; but these, being medical, are quite outside the province of this Society, and therefore I do not propose to discuss them, but to deal with the special meteorological features of these elevated regions, which exercise so remarkable an influence on human life.

Mountain climates, though classed together, vary in temperature, moisture, and wind prevalence, according to latitude, relation to land and water, and relation to other mountain ranges; but they have one common feature—to wit—diminished barometrical pressure, varying with the altitude, and itself giving rise to another peculiarity of mountain climates, diathermancy, which greatly influences animal and vegetable life; of this more will be said presently.

Naturally, too, we should expect that the atmosphere of mountains should be cooler than that of plains, and being cooler, it is incapable of holding in suspension as much moisture, and is therefore drier. Here again the position of the range comes in, for if, as in Assam, the mountain lies in the track of a wind laden with moisture, such as the South-west monsoon, the mountain causing the current to ascend, serves as a condenser, by lowering the temperature, and we get an annual rainfall, like that of Cherapunji, of 493 ins. If, on the other hand, it lies like the American Rockies to the lee of other ranges, such as the Sierra Nevada and Wahsatch mountains, the rainfall is moderate, and the climate dry.

There is another class of phenomena which is very remarkable in mountain climates, viz. the electrical, for from their position mountains are the natural conductors of terrestrial and atmospheric electricity, and it is no wonder that they are the scene of marvellous displays, as we shall hear when we allude to Pike's Peak.

The climate of Colorado is my text to-day, first, because I have lately returned from an interesting visit there, undertaken for the purpose of investigating the leading characteristics of the Rocky Mountains, and secondly because the situation of this chain in the heart of a great continent, far away from the sea or any large body of water, renders it especially fitted to serve as a type of a mountain climate. The annexed chart (Plate VI.), founded on a relief map of the United States, supplied to me free of cost by the Geological Survey at Washington, with that liberality which distinguishes the U. S. Government in all its scientific relations, will show that west of the Mississippi Valley a gradual rise takes place, which is still more marked when we reach longitude 99° W; the line of elevation extending from north to south of the United States; and here a height of from 2,000 to 5,000 ft. is reached. This comprises the vast prairie lands of North and South Dakota, Nebraska, Kansas, and part of Texas, a great portion of which are now cultivated farms. West of this we observe a further elevation, limited chiefly to the States of

Wyoming, Colorado, and New Mexico, of from 5,000 to 8,000, 11,000, and even over 14,000 ft. in the Rockies themselves. It is in these three States that we find the localities which are utilised, or likely to be utilised, as health resorts. The Rocky Mountains run nearly north and south, through British North America and the United States, and consist of a more or less distinct central chain and spurs running in various directions.

In the United States the range appears to bear different names in different States. In Montana it is called the Rocky Mountains, in North Wyoming the Bighorn Mountains, in South Wyoming the Black Hills, the spur running transversely from the main chain into the territory of Utah is called the Wahsatch Mountains, a portion of which is known as the Uintah Mountains and forms, with the last mentioned, a feature in the beautiful view from Salt Lake City. The range extends over a large portion of the State of Colorado, is penetrated by various valleys and streams, including the famous Rio Grande, and here rises to its greatest elevations; most of the grand peaks, Sierra Blanca, Mount Lincoln, Long's and Pike's and Gray's Peaks being situated within the confines of this State. The main range ends in the beautiful Spanish Peaks, but a portion, passing to the west, extends into Arizona, a large proportion of which State is elevated ground.

In the State of Colorado are various chains of the Rockies, two of which, running north and south, are called Front and Park ranges. These enclose between them the great natural parks—North, Middle, South, and San Luis Parks—which are wide valleys of pasture land at a high altitude, sheltered from winds, and surrounded by beautiful scenery. North Park stands at an elevation of 8,000 ft., and contains 2,500 square miles. Middle Park, which has a warmer climate, is 65 miles from north to south by 45 miles from east to west, and embraces about 3,000 square miles, 7,500 ft. above sea level. Communicating with it are Estes Park, Antelope and Manitou Parks, to which we shall refer presently.

Middle Park is enclosed by grand mountains; Long's and Gray's Peaks and Mount Lincoln; it contains beautiful meadow land and some celebrated sulphur springs. South Park is 60 miles long and 30 miles wide, including 2,200 square miles of, for the most part, pasture land, at an elevation of 9,000 ft., and it has a milder climate than the other two great parks. South of these is the San Luis Park, larger than all of them combined, and containing 18,000 square miles with an elevation not exceeding 7,000 ft., and its more southerly latitude, combined with a very abundant water supply, causes it to be more thickly wooded than the others.

All these parks enjoy fine climates; the wilder parts abound in elk, deer, mountain sheep, antelopes, bears, wolves, lynx, mountain lions, coyotes and beavers, and the streams supply plenty of trout. Cattle pasture all the year round without shelter or covering, and thrive on the abundant grass. It is supposed by Dr. Denison[1] that these parks were once beds of immense bodies of water, lakes in fact, which breaking through their rocky barriers cut deep

[1] *Rocky Mountains Health Resorts.*

rugged gorges or cañons, over which the rivers have flowed for centuries, depositing their *débris* in the foot hills and plains.

The deep gorges, or cañons, are a remarkable feature of the Rockies, as they may be found penetrating the chain in many directions. They are clearly the result of water action, and the various layers of strata cut through and exposed are well shown in the neighbourhood of Denver, where we have a good example in Clear Creek Cañon, where the river, starting from the base of Gray's Peak, has forced its way through a labyrinthine channel eastwards to the plain at Golden.

A grander cañon is that of the Arkansas, which is the line taken by the Denver and Rio Grande Railway in penetrating the Rockies. In parts, owing to the narrowness of the gorge and the great height and precipitous character of the giant granite cliffs and mountains through which the Arkansas threads its way, the scenery is magnificent. The forms of the rocks are specially fine, a specimen of which is seen, for instance, in the Currecanti needle, a fine pyramid of granite, and the mountain of the Holy Cross, which owes its name to the form of the Cross being delineated by snow accumulating in crevices in its rocky sides. The grandest piece of scenery on this route is the Royal Gorge, where the chasm is so narrow that there is only space for the river to flow through, and the railroad is therefore suspended by an ingenious bridge above it for some distance, the cliffs on either side reaching the height of 2,600 ft. Another striking mass of rocks is the Castle Gate, the fine portal by which the railway escapes from the gorges into the more open valleys on the western side of the Rockies.

This cañon of the Arkansas is surpassed in grandeur and wild magnificence by the great cañon of the Colorado, situate in Arizona, where that river boils and surges at the bottom of the greatest cañon in the world, one mile in depth, with nearly precipitous and beetling cliffs on either side, but this is outside of the State of Colorado.

The railways encircle, and in many cases penetrate into the region of the parks. The Denver and Rio Grande sends branches up several of the smaller cañons opening into them, while Middle Park is traversed by both the Denver and Rio Grande and by the Midland of Colorado, so that the district is rendered fairly accessible. Moreover the numerous towns, for the most part mining centres, like Leadville, scattered throughout the Rockies, or situated like Denver on the adjacent plains, amply supply the wants and necessities of residents and of camping out visitors.

The peaks of the Rocky Mountains vary in altitude from 13,500 ft. to 14,500 ft., the highest being the Sierra Blanca, which terminates the Sangre de Cristo chains; there being more than 100 peaks exceeding 13,500 ft. in height, and Gray's and Pike's and Long's Peak all exceed 14,000 ft., the general average being higher than in the Swiss Alps.

In appearance, however, they are not nearly so imposing as the Alps; they rise from a higher plateau varying from 5,000 to 6,000 ft. in height, their outlines are more rounded, the lower slopes, probably on account of the great dryness of the atmosphere, are less wooded, and for the same reason and also

because of the lower latitude the summits have less snow massed on them and no glaciers furrow their sides. The absence of cloud and mist causes their outlines to be very clearly defined even at great distances, and they form a fine feature at the ends of the tree-lined avenues of both Denver and Colorado Springs.

The geology and mineralogy of the Rocky Mountains are too complicated subjects for me to deal with, (especially as, according to the Denver and Rio Grande prospectuses, all known minerals are found there !) but the greater part consists of masses of granite rising beyond an outer stratum of red sandstone, which last forms the very weird and picturesque rock scenery of Monument Park and the Garden of the Gods among other instances. The colouring of both granite and sandstone is very vivid and rich in tone.

The Rockies, as will be seen by our maps, form the greater part of the State of Colorado, the eastern portion consisting of the Prairie, which extends far to the east and north, and in this State has an altitude of about 5,000 ft. Between Denver and Colorado Springs a spur of the range runs eastwards into the prairie called the Divide, in which lies Castle Rock, Perry Park and Palmer Lake, but south of this the great plain extends to the Gulf of Mexico, 800 miles.

We must therefore remember that in Colorado State there are four series of elevations, viz.:—

1. The snow clad peaks, 12,000 to 14,000 ft. and upwards in height, with a climate of their own.
2. The natural parks, varying from 7,000 to 10,000 ft. in altitude.
3. The foot hills and adjoining valleys, rising from 6,000 to 7,000 ft.
4. The prairie plains, varying from 5,000 to 6,000 ft.

The first class is of course useless for health station purposes, but the last three might be made available and offer an infinite variety of altitude and of climate.

Having described the general conformation of the country, we come to its meteorology as a whole, and the annexed map (p. 70) of the Weather Bureau of the United States will give some idea of the distribution of the rainfall.

In Colorado the rainfall varies from 8·71 ins. to 22·30 ins., at Denver it is 14·17 ins., at Colorado Springs 15·17 ins., and at Santa Fé, the capital of New Mexico, 14·17 ins. It does not appear to increase with altitude, for Gunnison, 7,680 ft. in the heart of the mountains, has only 10·02 ins., and Leadville, at 10,200 ft., only 12·80 ins. Georgetown has 14·39 ins. ; Pike's Peak, with its great elevation and consequent liability to act as a condenser, has a larger rainfall, viz. 29·18 ins., but this is after all small in comparison with other high peaks. The western stations, such as Fort Lewis, seem to have larger rainfall than the eastern.

Throughout Colorado scarcely any rain falls from October to April, and the greater part is precipitated during the thunderstorms which are so frequent from May to September. Snow occasionally falls in autumn and winter, but except at the higher levels, does not lie.

Relative humidity returns from several portions of the State show a percentage varying from 46 to 58 per cent., contrasting with those of the Pacific Coast, such as at San Francisco 78, and at St. Louis, in the valley of the Missisippi, 78, or on the Atlantic, as exemplified by New York, 75 per cent.

Mean Annual Rainfall of the Western States.

The average amount of cloudiness in Colorado, as given in Dr. Denison's Charts, is also very small; whether the season be spring, summer, autumn or winter, it always shows a percentage far less than that of either coast line. The number of days on which rain falls is about 85, but on many of these the day is fine generally, with an evening storm.

The temperature shows great extremes, and, as might be expected in a mountainous region removed from all equalising influences, such as that of the sea, the nocturnal radiation is considerable. The mean annual temperature of Denver is 50°; the maximum reading, occurring in July, being 100°, and the minimum, 7°, in February.

The monthly means are as follows :—

		°			°
January	...	27·2	July ...	...	72·0
February	...	29·6	August	...	72·8
March ...	...	43·3	September	...	60·0
April ...	...	51·1	October	...	51·8
May ...	...	55·5	November	...	32·4
June ...	...	64·3	December	...	40·5

The summers are warm, tempered by showers, as most of the rain falls in summer and spring. The autumn is fine with, perhaps, some frosty nights, but very sunny and warm by day. There is practically no winter till January, and then but little snow, which the powerful sun usually soon melts, though nocturnal frosts are frequent and very severe, but the striking feature is the range of temperature, which amounts at Denver occasionally to 107°, and has been known in some stations of Colorado to reach 118°.

The minimum has been known to fall to −25°, this was in January 1876, and 101° is the highest maximum recorded. Wind is undoubtedly present, and may be almost said to be a feature of the climate, though some spots are completely protected. The wind prevailing is the South, and the average wind force for the year is 7. Only between 30 and 40 days are reported as absolutely calm, so the climate may be considered as by no means devoid of aerial movement.

The number of fine days is one of its strongest recommendations, and I see the Weather Bureau for 1889 records for Colorado Springs 171 cloudless days, 135 partly clouded ones, and 59 cloudy.

These figures all point to a very dry climate, with small rainfall and relative humidity and great absence of cloud and vapour ; and a glance at the relief and rainfall maps will explain this peculiarity. The usual rain-bringing winds come from the Pacific coast, where it will be noted that the rainfall is comparatively large, but before they reach Colorado State, and more especially the parks and plains, they are driven upwards over the Sierras, which condense much of their moisture ; next they have to cross 60 miles of the great American desert, which is not likely to add to their humidity ; then they are deviated upwards again by the Wahsatch Mountains, and passing at an altitude of at least 13,000 and 14,000 ft. over the Rockies, they arrive at Colorado as dry, and for the most part warm, winds. The country to the east is a vast plain gradually descending to the Mississippi valley, and on the whole dry, the only source of moisture being the Gulf of Mexico, 800 miles off ; the consequence is that Colorado and New Mexico enjoy remarkably dry and cloudless climates, and are also extremely sunny regions. The hours of sunshine far exceed in number those which can be counted at most European resorts. Dr. Solly gives a table of temperatures indicated by the solar radiation thermometer during the year 1886-7.

	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
	°	°	°	°	°	°	°	°	°	°	°	°
Highest temperature	137	155	152	135	124	110	112	123	114	121	124	129
Lowest temperature	110	138	133	118	104	94	97	95	101	108	98	101

We shall now consider our first class of climates, that of the snowy peaks of the Rockies, and the enterprise and energy of the American Government has supplied unequalled records in this respect, as for 14 years they maintained the meteorological observatory at the summit of Pike's Peak, 14,147 ft. above sea level, the highest observatory in the world, where regular and careful observations have been made by the officials of the Weather Bureau. The station has since been abandoned, but I understand it is to be reopened this year. Meteorological energy has been equalled by engineering, and a cogwheel railway, with a wonderfully adapted locomotive, conducts visitors to the summit during the summer, though the snow compels the closure of the line in winter.

Pike's Peak is of granite, and on the somewhat flat summit are strewn great blocks of this formation. Snow is always present in patches, but there are no glaciers. The barometer shows 17·54 ins. of pressure.

A remarkable feature of the Pike's Peak records is the resemblance between the recurring annual phases of atmospheric pressure and of the air temperature.

The curves of these are not only alike in having a single bend, but the maximum of both occurs in July, and the minimum of both in January.

The mean monthly pressure rises and falls ·016 in. for every degree Fahrenheit of the monthly mean temperature. Similar phenomena have been noted on Mount Washington (6,279 ft.), another lofty observatory of the United States situated in New Hampshire, in the Eastern States. It has also been found that actual barometric pressure in the Rocky Mountains, generally at altitudes above 4,000 ft., attains its minimum in January, and its maximum in July or August, and that the barometric phases are of the same kind, in reference to the annual mean, as the temperature phases at such stations. This phenomenon of atmospheric pressure is the reverse of that in parts of the United States at low elevation, and results, according to General Greely,[1] from the lower average temperature of the winter months contracting the great body of air so that much of it is brought below the summit of the mountains, while in summer the reverse conditions obtain.

The highest temperature on Pike's Peak was 64°, noted on July 19th, 1879; the lowest —39°, noted December 21st, 1887; the mean temperature being 19°·3. This has ranged during the 14 years from 17°·9 to 21°·9.

It may be interesting to note that Mount Washington during the same 14 years had a maximum of 74° and a minimum of −50°, showing at a considerably lower temperature greater extremes.

The maximum daily range of temperature on Pike's Peak takes place in July and August, being 14°·3 and 14°·2 for each month respectively. The minimum range is in December (11°·6). Thus the mean daily range on Pike's Peak is about half that noted on the prairie plains, on which Denver and Colorado Springs are situated.

The rainfall on Pike's Peak has been stated to be 29 ins., of which the minimum (1·39 in.) is in February, and the maximum (4·46 ins.) in July.

[1] *American Weather.*

33 per cent. falls in spring, 35 per cent. in summer, the remaining 32 per cent. being distributed equally between autumn and winter, these seasons exhibiting the same dryness as at Denver and Colorado Springs.

The winds are chiefly Westerly, 31 per cent are from South-west, 20 per cent. from West, 21 per cent. from North-west, 10 per cent. from the North, 8 per cent. from the North-east, 5 per cent. from the South, and the rest are distributed among the East and South-east and calms.

This contrasts with Colorado Springs, nearly at the foot of Pike's Peak, where the most prevalent winds are the North (27 per cent.) and the South-east (22 per cent.); showing the effects of local currents.

The velocity of the wind varies from a mean of 26·6 miles in January to one of 12·3 miles in August. The highest mean monthly velocity occurs with the lowest mean monthly temperature, and the least mean velocity with the highest mean temperature. Severe and prolonged wind storms are rare at the summit of Pike's Peak, and the days are few when the mean hourly velocity equals or exceeds 50 miles. In two storms in 14 years it ranged 70 and 71 miles an hour, and once, on May 11th, 1881, it reached 112 miles.

Mount Washington, on the other hand, has stronger winds and they prevail longer; velocities of 116 miles have been recorded, and on one occasion the great rate of 186 miles.

The most interesting part of the meteorological diary on Pike's Peak is the record of the electrical phenomena, and as abridgment would spoil the pure American style in which the narrative is written, I give some extracts.

February 24, 1874.—Summit continued enveloped in snow clouds till 2 p.m. As a curious illustration of the rapidity with which water boils at this elevation, the observer notes that this evening a dish pan full of loose snow was set on the hot stove to melt, and in a very short time the water in the bottom of the pan began to boil, while the snow on the top of it was yet 3 or 4 inches deep. On examination it was found that a solid crust had formed above the boiling water, and even this was not sufficient to condense all the steam, which escaped with loud hisses from its icy confines.

May 29, 1874.—At noon the summit became densely enveloped, and sleet fell in short showers till evening, while the rumbling of distant thunder was occasionally heard to the south. At 6 p.m. a storm began which will long be remembered by the present occupiers of the station. A violent thunderstorm, accompanied by heavy sleet, passed over the peak from south-south-east to north-north-west. It came up so suddenly that there was barely time to cut out the telegraphic instruments before blinding flashes of fire came into both rooms from the lightning arrester and stoves; loud reports followed in rapid succession, while outside the noise of thunderclaps was almost drowned by the rattling of the indescribably heavy showers of sleet which followed each discharge. The storm appeared to surround the peak in all directions. At 7 p.m. a bolt struck close to the north window, and at the same time a heavy discharge took place through the lightning arrester, which made it appear that the building had been struck and was on fire. A cloud of smoke filled the embrasure of the north window, which was afterwards found to have resulted from the melting of rubber insulation on the office wires.

After this discharge the storm passed slowly to the west. The observers were beginning to breathe more freely when the wind veered to the South-west, and brought back the storm in all its fury. The rattling of torrents of sleet, mingled with the incessant rolls of thunder, the blinding flashes and loud reports in the rooms, were enough to make the stoutest heart quail.

It has been noticed, by closely watching the beginnings of storms which were so frequent during the latter part of May and not uncommon during June, that

the great majority of them originated over the extensive parks west, south-west and north-west of this peak, and dividing it from the main range. The lower strata of air become powerfully heated, and are probably at this season of the year, when the surrounding mountains discharge their melting snows into the parks, heavily charged with moisture. The cold, heavy West winds descending the eastern slope of the main range, and wedging under the heated, moist, lower strata, might explain the frequency of local storms on the peak during the hottest part of the day.

February 14, 1881.—Fog in morning and afternoon. Four mock moons appeared on different sides of the moon at night, at equal distances from that body and from one another. These increased in intensity of colours until they were brighter than the moon itself, which appeared as if hidden behind a veil. By-and-by bows as brilliant as those of the sun appeared over each, which increased in size until they almost joined, and formed a perfect circle of the most brilliant colours. These gave way for double halos, the second being nearer to the first than that was to the moon. Both were of a beautiful violet tint. When the moon had risen about two-thirds of the distance between the horizon and zenith, these rings disappeared and a new one appeared much further removed from the body, the refraction of whose light produced these fantastic shapes. The new halo was much paler than those it had succeeded; it was the precursor of one of the most magnificent refractions of light that any human being ever witnessed. Near the moon appeared two mock moons, shining like balls of fire, and in the horizon opposite these were reproduced, but in a milder colour. A halo of a mild pink colour passed through the plane of these four mock moons and intersected the main halo. To complete the display a bow appeared at the zenith, and this was as brilliant as a rainbow, and comprised all the colours of that bow of promise.

June 7, 1882.—During a violent thunderstorm, while sleet was falling a "singing" or "sizzing" noise on the wire was distinctly heard. At 8.45 p.m. on opening the door, the line on the summit was distinctly outlined in brilliant light, which was thrown out from the wire in beautiful scintillations. On near approach to the wire these little jets of flame could be plainly observed. They presented the appearance of little electrified brushes or inverted cones of light, or more properly, little funnels of light with their points to the line, from which they issued in little streams about the size of a pencil lead, and of the brightest violet colour, while the cone of rays was of a brilliant rose white colour. These little cones of light pointed from the line in all directions, and were constantly jumping from point to point. There was no heat to the light, though it was impossible to touch one of these little flames, for as soon as they were approached by the finger they would instantly vanish, or jump to another point of the line. Passing along the line with finger extended, these little jets of flame were successively puffed out, to be instantly relighted in the rear. It was a curious and wonderful sight. No sensation was experienced on applying the tongue to the line. Not only was the wire outlined in this manner, but every exposed metallic point or surface was similarly tipped or covered. The cups of the anemometer, which were revolving rapidly, appeared as one solid ring of fire, from which issued a loud rushing and hissing sound. The anemoscope represented a flaming arrow, and a small round wooden stake stuck up in the snow to show the position of the gauge was similarly tipped, as well as an angle of our stone chimney. Observer, on placing his hands close over the revolving cups of the anemometer, where the electrical excitement was abundant, did not discover the slightest sensation of heat, but his hands became instantly aflame. On raising them and spreading his fingers, each of them became tipped with one or more cones of light, nearly 3 ins. in length. The flames issued from his fingers with a rushing noise, similar to that produced by blowing briskly against the end of the finger when placed lightly against the lips, accompanied by a crackling sound.

There was a feeling as of a current of vapour escaping, with a slight tingling sensation. The wristband of his woollen shirt, as soon as it became damp, formed a fiery ring around his arm, while his moustache was electrified so as to make a veritable lantern of his face. The phenomenon was preceded by lightning and thunder, and was accompanied by a dense driving snow, and disappeared suddenly at 8.55 p.m., with the cessation of snow.

June 9.—Repetition and previously defined sensations, and the observer's hair stood erect, crackled, and the pricking sensation to the scalp (bareheaded) was extremely painful. The peculiar electrical odour was strongly recognised. To protect his head, he put on his black felt hat and returned to the roof. But a few seconds elapsed before he was fairly lifted off his feet by the electrical fluid piercing through the top of his hat, giving him such a sudden and fiery thrust that he nearly fell from the roof in the excitement. Instantly snatching the hat from his head, he observed a beam of light, as thick as a lead pencil, which seemed to pass through the hat, projecting to about an inch on either side, and which remained visible for several seconds. The top of his hat was at least 2 ins. from his head when this fiery lance pierced him. When the fluid began to thrust its fiery tongues into other parts of his body, he was spurred to a hasty, but "brilliant" retreat. He experienced a peculiar burning or stinging sensation of the scalp for several hours afterwards. The phenomenon lasted 15 minutes. Lightning and thunder were continuous during the evening; the sharpest flashes drew from the metallic roof loud snapping sounds.

November 17, 1882.—Aurora this morning at 4.30 a.m. The arc was about 12° high in the centre. The one end extended nearly to the eastern horizon, the western one being hidden by the mountains. Along the eastern part luminous beams shot up from 15° to 20°. For a time it looked like a veil or sheet of pale light, but before fading it became very bright. A wide band of light from the sun extended nearly to the zenith, although nearly two hours before the sunrise. Ended 6 a.m. About 4.45 a.m. the "singing" or humming noise began on the telegraph wires, and became very loud. Aurora began to-night at 6.15 p.m. It appeared in the form of an irregular greenish-white cloud along the northern horizon, and under it was a very dark space. Above and apparently issuing from the green light, in different places, was an intensely red light, almost of a blood colour. These red spaces were probably 15° wide and from 15° to 18° high. Near these beams of white light extended to the zenith. The red would alternately fade and re-appear, until finally it remained stationary at the west end of the clouds, fading and appearing in rapid succession until 8.30 p.m., at which time the white cloud appeared to break up into beams or groups of beams, which were probably from 15° to 20° in height. At this time the red light at the western part was intensely bright, and all gradually faded, the white colours settling down into a regular arch of about 15° high in the centre, and remained so. Aurora steadily disappeared at 11 p.m.

We next come to the climate of the natural parks, varying in altitude from 7,000 to 10,000 ft. Unfortunately I have only imperfect meteorological records, as there has hitherto been no station of the Weather Bureau in North or Middle Park. One has been recently established in South Park near Como, but I do not know its altitude, and the information from there, except as to rainfall, is incomplete. These parks extend from 37° to 41° N. latitude and are of different elevations, so that considerable choice of climate may be found in them. In many places the vegetation shows an excellent soil, a good supply of water, shelter from winds, and freedom from the great cold of the higher peaks.

The Weather Bureau gives, among reports by voluntary observers, a year's observations made at San Luis, a small town situated at an elevation of 7,946 ft. in San Luis Park at the extreme south of Colorado State, and these I have analysed with the following results:—

The annual mean temperature is 41°·7, the mean maximum 70°, the temperature rising in June and July to above 90°, and falling in December and January to −25°; the mean minimum being 8°·28. The annual rainfall is 13½ ins., occurring principally in September, December (when 2½ in. falls), March, and April.

At Como (Middle Park) the rainfall is less, being 11·64 ins., but it occurs chiefly in summer, as on the plains.

I explored Estes and Manitou Parks, and perhaps an account of my visit to one of them, may enable you to picture them to yourselves better than a minute description. Let us take Estes Park, which is close to Long's Peak, and the greater part of which belongs to an English company, of which Lord Dunraven and Captain Whyte are the principal directors.

We left Denver one fine October morning, and after three hours by rail, journeying northwards, we reached Lyons, a small timber built town in the foot hills, the present terminus of the railway, which it is contemplated to continue up to Estes Park itself. Quitting the rail we ascended an excellent road in a winding valley, through which the Little Thompson River flows out from Estes Park. We first passed some grand masses of red sandstone, which, as is common in the Rockies, rise precipitously, ending in pinnacles, resembling castles and ramparts of fortresses and the like, and soon we reached the rocks of granite formation.

The sinuous valley was well wooded with scrub oak, in October of bronze to scarlet hue, with golden-tinted cotton trees, a species of poplar very common in the States, with what they call cedars, a sort of cypress ; and strewn about were huge boulders, brilliant with ferns and mosses, and wreathed with clematis, which had fallen from the beetling cliffs on either side. As we drove upwards the cotton trees and cedars gave place to pines of various kinds, some of great size, and here we made the acquaintance of some of the natives, the grey squirrel, the chipmunk, a lively little animal about half the size of our squirrel, with a long bushy tail striped in two shades of greyish brown. They were skipping about the larch fences in which they delight. The beautiful American jay, with its brilliant blue plumage, flew from tree to tree. We passed the entrance to Antelope Park, another fine pasture land, and came into more open country with numerous ranches ; before each farm house was a pile of stag horns shed by the deer in the adjacent mountains, and collected by the farmers.

After four hours' ascent through beautiful scenery we reached the portals of Estes Park, and found ourselves descending into a magnificent basin of park-like country, interpersed with several species of pines, and backed by grand mountains.

The park is an irregular shaped depression with various recesses, and measures 10 miles in its greatest diameter and 4 miles in its smallest. It is undulating and carpeted with excellent grass, but some fine wooded eminences rise in parts. Surrounding it is a remarkable circle of rocks, behind lie the grand mountains ; to the south Long's Peak (14,271 ft.), to the west Mount Upsilon, then Mount Kenry, named after the Earl of Dunraven, and the Mummy Mount, and on the north, Mount Signal, and to the east the granite form of Mount Olympus.

The Thompson River, a moderate sized trout stream, flows through Estes Park, and there are several small lakes. On the south side rises a fine wooded hill called Prospect Hill, up which we saw a coyote stealing (a coyote being an animal something between a wolf and a fox).

The park itself stands at an elevation of 7,500 ft., and contains an hotel and Captain Whyte's house, where we were most hospitably entertained, as well as several ranches, and in summer a large number of visitors camp out for shooting and fishing purposes. There is plenty of fish and game. Deer had been down in the park the day we arrived, and, what was more rare, a herd of mountain sheep had appeared on one of the crags above Captain Whyte's house. Beavers, of which we saw the traces, abounded, and had built their dams so effectually as to cause some trouble by diverting part of the stream destined for irrigation. Coyotes skulk about but do not seem to do much harm, though the wire meat safes must always be placed at a height beyond their reach. We drove across the beautiful park in several directions, generally over the grass, then burnt up after the long summer, and we selected the site for a proposed new hotel, and saw Captain Whyte's fine herd of 400 red Herefordshire cattle, all in excellent condition. He told me that they fatten on the good herbage, and lie out all the winter without shed or stable. The cattle apparently were very healthy, and had become thoroughly acclimatised. That night we had a sharp frost, which covered the ranche's pond with ¾ in. of ice, but hardly whitened the trees, and before sunrise next morning I witnessed a splendid Alpine glow on the surrounding peaks, and then the sun rose gloriously in a clear sky, flooding the whole park with the golden beams, and imparting plenty of warmth to us all. From the information I could gather from the residents, the climate is never excessively cold, as appears in the San Luis Park observations, and there is but little wind, the mountains, which do not overshadow, effectually sheltering the park. The rainfall is small, and snow does not lie on the ground for any time.

A great advantage are the endless excursions, not only in the park itself, but into the beautiful valleys which open into it, the Black Cañon and the Horse Shoe Valley for instance;—excursions replete with interest for the artist, the sportsman, and the man of science.

At present these parks are used chiefly in summer, when the dwellers in cities, like Denver, flock to them and camp out during the two hottest months, but it is contemplated to utilise them during a longer part of the year, as being well suited for more active and less delicate invalids. There is at present accommodation in Estes Park, but more is forthcoming in the shape of a new well-appointed hotel to be kept open all the year round. The present hotel has 50 beds and several ranches with cottages attached, Ferguson's, Macgregor's and James's (late Elkhorn), also lodge invalids with tolerable comfort and at a moderate cost. There is a post daily bringing letters and parcels.

Manitou Park lies 8,000 ft. high, 26 miles from Colorado Springs, and rather nearer to Manitou, up the Ute Pass, with a fine view of Pike's Peak. It is about 10 miles in length and 4 in breadth, and is one of the approaches to Middle Park.

The scenery much resembles that of Estes Park, and the neighbourhood abounds in large game, such as elk and deer. There is an excellent hotel

and a number of wooden cottages, which are used by visitors in summer, when the place is a great camping centre.

A picturesque line of rail, the Colorado Midland, connects Woodland Park Station with Colorado Springs, and then a 9 mile drive, partly through lovely fir woods, leads to Manitou Park, which is much recommended by the medical men of Colorado Springs.

Our third class of elevations, the Foot-hills, an expressive term, may be considered in conjunction with the fourth, the prairie plains, the difference being that the climate of the former is rather cooler.

The third and fourth class comprise all the Colorado plains of an elevation of 5,000 ft. and upwards, and the towns situated on them, such as Denver, Longmont, Boulder, Golden, Colorado Springs, Manitou, and the various settlements on the foot-hills.

The climates of Denver and of Colorado Springs, as set forth in the admirable meteorological reports of the Weather Bureau, have been well examined by Drs. Denison and Solly, and may be considered as typical of the true Colorado climate, the principal features of which have been already given.

The prairie in which these towns lie is as remarkable for its vastness as for its colouring. When standing on any elevated spot, one sees it is not a flat surface, but presents here and there undulations, though stretching away, as it does, for hundreds of miles north, east, and south, these are sometimes hardly visible, and the general impression is of some great billowy moving sea which has suddenly become petrified.

The sun rising in the east floods the vast plain with its rays and turns it a brilliant golden colour beautiful to behold, and gradually as the shadows extend, tints of red, purple, and brown appear and advance in great lines across the plain, while with the setting sun the colouring becomes first orange, then red, then purple, changing at last from delicate pearly tints to cold grey. The sky also undergoes the most brilliant changes, passing from the usual sunset phases to an exquisite violet which suffuses successive portions of the sky long after the sun has set. The vault of heaven appears of boundless height, and the air is so transparent that objects 20 miles off appear close at hand, and Pike's Peak, 75 miles distant from Denver, is quite distinct, indeed some of the fine peaks seen from that city are calculated to be more than 120 miles off.

Another feature of this vast plain is the absence of life. You may travel for miles and miles and see nothing but an occasional prairie dog village, with its little fat denizens sitting up on the tops of their mounds, with their paws hanging in front, looking like posts, so unmoved are they, even when the locomotive rushes past; after awhile a few cattle are to be discerned, then a mounted cowboy, looking larger than human from his solitariness—but the general feature of the prairie is its intense solitude.

The vegetation consists of buffalo grass, several varieties of cactus, a small kind of yucca, and what is called the prairie flower, besides lilies and other summer blooming flowers.

Driving in a light buggy with a pair of fast cobs is very pleasant, provided you hold on tight, as it is not uncommon to descend into a prairie dog's hole, or worse still into a dry creek or water bed, where the jolting is considerable, for the horses delight in the grassy trail, and fly through the air at a tremendous pace.

As I have said before, the prairie is undergoing cultivation; by means of sinking artesian wells and bringing water from the mountains, the plains are gradually being supplied with irrigation water, and are made to produce a better grass as well as wheat and Indian corn; a little less cactus, a little more alfalfa everywhere, this last being the usual western food for cattle, but it will be long before the prairie is transformed into great farms.

Denver is situated in the prairie on the small river of South Platte, and though only about 30 years old, is a city of 150,000 inhabitants with fine buildings, capital schools, excellent clubs, theatres, monster hotels, cable and electric cars, electric lighting, and all the advantages of American civilisation. The streets are well planned and many are paved with asphalte, the avenues are wide and many are lined with trees and command fine views of the Rocky Mountains. The city extends over at least 5 miles, and though parts of it are smoky, owing to the ore smelting and other works, the suburbs, which are remarkably open and only bounded by the prairie, are charming and suitable for invalids' residence. The medical profession is well represented, while a completely equipped faculty of medicine exists in the University of Denver, and all accorded a warm welcome to your President. I may add that many of these doctors are instances of consumption cured by the climate.

There are also a number of boarding houses in the small towns and ranches in the Foot Hills and up the cañons, where Denver medical men place their patients with advantage, such as the following:—Stewart's ranch in Bear Cañon (7,000 ft.) about 20 miles from Denver, Longmont (5,000 ft.), a small town with good water and lighting, and near it an excellent moderate pension called Hygiea. Boulder (5,409 ft.), at the mouth of the romantic Boulder Cañon, is a small town with a university 29 miles from Denver, and has suitable accommodation with charming excursions up the adjoining valley. Greely and Fort Collins, at a little lower elevation and some 50 to 60 miles to the north of Denver, have been well spoken of for invalids.

Idaho Springs (7,800 ft.) in the Clear Creek Cañon is strongly recommended by Dr. Denison, and stands on a plateau well sheltered by mountains, having remarkable saline and ferruginous springs, used for baths and drinking, and, like most of the preceding, is connected with Denver by rail. There is a very good hotel at Perry Park (6,000 ft.), situated on a spur of the Rockies called the Divide, which separates the basins of the South Platte and the Arkansas rivers, about 40 miles south of Denver, and there are many others, one of the great advantages being the extensive rail communication in all directions with Denver.

Colorado Springs is situated on the prairie, at an altitude of 6,022 ft., 75 miles south of Denver, 5 miles from the foot-hills of the Rockies, and 6

miles from the base of Pike's Peak, which forms so fine a feature in the view from the town. It has a population of 13,000, and no manufactories, and consequently no smoke. The town is laid out picturesquely in avenues from 60 to 120 ft. in breadth, lined with a double row of trees which run north, south, east, and west, thus intersecting each other, the main roads being traversed by electric cars. The buildings are handsome, and especially the private houses are artistic, many of red sandstone and surrounded by gardens. Cascade Avenue is a fine street composed of houses mostly built by consumptives, who have selected this as their residence. There is a top soil of 2 ft. and gravel and sand to an average depth of 60 ft. below, and consequently all moisture drains away rapidly. The main drainage—and the plumbing, as our American cousins call it—is good, and the water supply is excellent, the water being brought from the mountains in iron pipes.

To the north of the town lies the Divide, which gives some protection from Northerly winds, to the south the open prairie, to the east the prairie on which rises a low range of hills called Austin's Bluffs, and to the west and south-west the great masses of Pike's Peak, Mount Rosa, named after Miss Kingsley, and the beautiful Cheyenne Mountain, with the foot-hills in front of them.

Intervening between these grand mountains and the town are Colorado City, and rather to the north of it the celebrated Garden of the Gods, Monument Park and Glen Eyrie, with the fantastically shaped red sandstone rocks, while nestling under the very mountains, surrounded by more timber than is usual in Colorado, lies Manitou Springs, about 1,000 ft. higher than Colorado Springs, where the mineral springs really do exist and of delicious quality, whereas there are none at Colorado Springs, the title of which is a misnomer.

The mean temperature of Colorado Springs is 46°·4, but it is composed of considerable extremes. The maximum rises to 101°, the minimum falls to −25°, but curiously the extremes do not appear to be much felt, perhaps owing to the dryness. The mean rainfall for 10 years is 15·87 ins., and of this about 12 ins. falls in spring and summer, generally in thunderstorms; only 4 ins. are noted between September and March. Snow, as a rule, disappears by evaporation in the sunshine. The number of clear days is 194, of fair days 128, and of cloudy 43. The sun shines during 330 days of the year, and for 165 days out of the 182 from October 1st to April 1st, so that on an average an invalid is deprived of sunshine for less than half-a-day a week in winter. The power of the sun is great, and during the entire winter ladies need parasols and invalids sit in the open piazzas, which are a feature of the houses, without extra wraps. The wind is the most troublesome item of the climate, and generally rises in the afternoon. The annual mean velocity is 8·58 miles per hour.

Dr. Solly[1] gives an admirable account of an invalid's day in midwinter, *i.e.* from 9 a.m. to 4 p.m., which I venture to quote.

"After a night in which there has been a hard frost and a clear sky, with a light breeze from the North, and during which the invalid has usually slept

[1] *Facts, Medical and General, about Colorado Springs.*

soundly under several blankets, with his window partly open, he wakes up to find the sun shining at his eastern window. And this is a feature which, whatever the weather may be later in the day, is rarely absent. After breakfast our invalid steps into the street, being then in an atmosphere in which the heat in the sun is 92°, and in the shade 30°. A gentle air is stirring from the North-east at the rate of 8 miles an hour. The mean dew point is 18°.

"As the day proceeds the temperature rises to its highest point, between 3 and 4 p.m. being 100° in the sun, and 40° in the shade, while the wind, which has veered rapidly from the North to the South, blows with its highest daily velocity of 13 miles an hour. After 2 p.m. the wind works back again towards the East, being at sundown North-east, and continuing as darkness falls to shift back to the Northern quarter, whence it blows from 8 p.m. to 9 a.m., its velocity dropping to between 7 and 8 miles an hour; the temperature of the air at the same time falling from 8° to 4°.

The ground is usually bare of snow; no rain falls from mid-September to mid-April, and the sun shines unobstructed by clouds. During the three winter months the cloudy days do not average more than three a month."

Accommodation is excellent and plentiful, and there are several able and experienced medical men, including Dr. Solly, to whom Colorado Springs owes so much. The excursions to be made are endless and charming. The cañons of the Cheyenne Mountain present lovely scenery of trees, granite needles, and waterfalls, the Ute Pass is grand, but the finest of all is Pike's Peak itself with its neighbouring valleys, which is daily ascended by rail in summer. Riding and driving are the chief exercise used, and the Broadmoor Casino with its boating on the lake, its music, and its races, furnishes amusement, while for the vigorous, the mountains and parks within easy distance offer plenty of shooting and fishing.

Manitou Springs is somewhat better protected by the mountains from wind, though it enjoys sunshine for a shorter period of the day than Colorado Springs. The annual mean temperature is 47°·3, the maximum, 96°, occurring in July, and the minimum, 23°, in January. The relative humidity is 54 per cent. The rainfall, of which I was unable to procure statistics, is probably low.

It is a pretty little place, with some most valuable mineral waters and excellent hotels. It is also the starting point for several suitable summer stations on the Ute Pass, such as Cascade Cañon, Ute Park, Green Mountain Falls, and Woodland Park, all of which have good hotels placed at various elevations above Manitou.

The above description will, I hope, give a sample of the climate of Colorado and afford some explanation of its probable factors.

The chief elements appear to be—

1. Diminished barometric pressure, owing to altitude, which throughout the greater part of the State does not fall below 5,000 ft.

2. Great atmospheric dryness, especially in winter and autumn, as shown by the small rainfall and the low percentage of relative humidity.

3. Clearness of atmosphere and absence of fog or cloud.

4. Abundant sunshine all the year round, but especially in winter and autumn.

5. Marked diathermancy of the atmosphere, or, as Dr. Denison expresses it, "the increased facility by which the solar rays are transmitted

through an attenuated air," producing an increase in the difference of sun and shade temperatures varying with the elevation in the proportion of 1° for every rise of 285 ft.

6. Considerable air movement, even in the middle of summer, which promotes evaporation and tempers the solar heat.

7. The presence of a large amount of atmospheric electricity.

Thus the climate of Colorado is dry and sunny, with bracing and energising qualities, permitting outdoor exercise every day all the year round, the favourable results of which may be seen in the large number of former consumptives whom it has rescued from the life of invalidism and converted into healthy active workers. Its stimulating and exhilarating influence may also be traced in the wonderful enterprise and unceasing labour which the Colorado people have shown in developing the riches, agricultural and mineral, of their country. Let us take the latter alone: In 1890 30 millions of dollars, or £6,000,000 sterling, worth of precious metals, was mined in the State of Colorado, which is larger than the United Kingdom and Ireland and at present numbers only 500,000 population. Thirty years ago Denver may be said not to have existed. Now it is a well built, well organised city of 150,000 inhabitants.

Surely we may claim some of these results as the effect of this magnificent climate on the Anglo-Saxon race, while the Colorado people are as kindly and generous as they are energetic and enterprising, and a warm welcome awaits all visitors and settlers from the old country, who may certainly hope to procure health, and possibly also wealth, in this rising State. Well may we here, as in other cases, render homage to the Empire of Climate.

REPORT OF THE COUNCIL

FOR THE YEAR 1892.

In presenting their Report the Council, while congratulating the Society on its progress during the past year, cannot but express their deep regret at the deaths within the year of two of their colleagues. The losses which the Council have sustained in the deaths of Dr. Tripe on April 7th, and of Mr. Marten on November 3rd, have been very serious. Dr. Tripe joined the Society in 1856, and since 1858, with the exception of a single year, was always in office, 3 years as Member of Council, 6 years as Vice-President, 2 years as President, and 23 years as Secretary, in all 34 years. It is not too much to say that by his devotion to the interests of the Society, and his uniform courtesy, he inspired everyone with whom he came in contact with respect and affection. Mr. Marten had only been a Fellow for 12 years, but his business habits and great experience pointed him out as one likely in the future to hold high office in the Council, and his colleagues cannot help regretting the death of one whom they esteemed so highly. There had been no death vacancy in their number for 12 years, not since the death of Sir Antonio Brady, one of the Trustees, which occurred on December 12th, 1881.

To fill the vacancy caused by the death of Dr. Tripe, the Council, under By-Law 5, on May 18th elected Mr. Bayard as their Secretary, to hold office until the present Annual Meeting.

A reprint of the By-Laws being necessary, the Council considered the opportunity favourable for abolishing the office of Trustees, and for having the Society's property transferred into its own name in accordance with the Charter. They therefore prepared a revision of the By-Laws, which was sanctioned at a Special General Meeting of the Society, on November 16th, and the matter has now been completed by the transfer of the Society's funds into its own name. The Council feel sure that the Fellows will accord the retiring Trustees, the Hon. F. A. Rollo Russell and Mr. Silver, a hearty vote of thanks for their care of the Society's funds in the past.

The Council have been materially assisted by several Committees, which were constituted as follows :—

General Purposes Committee.—President, Secretaries, Foreign Secretary, Treasurer, Messrs. Brewin, Ellis, and Inwards.

Editing Committee.—Messrs. Inwards, Maclear, and Scott.

Exhibition Committee.—President, Secretaries, Messrs. Ellis, Marcet, Scott, Strachan, and Whipple.

Stations Committee.—President, Secretaries, Messrs. Ellis, C. Harding, Mawley, and Scott.

Thunderstorm Committee.—President, Secretaries, Messrs. Clayden, Ellis, Inwards, and Scott.

Wind Force Committee.—President, Secretaries, Messrs. Binnie, Chatterton, Dines, C. Harding, Laughton, Munro, Scott, and Mr Whipple as representing the Kew Committee.

Annual Exhibition of Instruments.—A large and interesting Exhibition of Instruments relating to Climatology was arranged in the rooms of the Institution of Civil Engineers on Tuesday, March 15th, and remained open till the following Tuesday. There were 106 exhibits, which were classified as follows :—(1). Thermometers and Screens; (2). Sunshine Recorders and Actinometers; (3). Solar Radiation Instruments; (4). Hygrometers; (5). Rain Gauges; (6). Barometers; (7). Anemometers; (8). Models, &c.; (9). Maps and Diagrams; (10). Photographs. In connection with the Exhibition the President (Dr. Williams) read an interesting paper on "The value of Meteorological Instruments in the selection of Health Resorts," which was illustrated by a series of photographs of the Stations on the Riviera. The Meeting was extremely well attended.

Stations.—Observations have been accepted from the following stations :—Ardgillan, Co. Dublin; North Thoresby, Lincolnshire; and Taunton, Somerset. The observations have been discontinued at Plymouth, Devon; and Southampton, Hants.

Copies of detailed monthly returns and annual summaries of results have been supplied as usual to the Meteorological Office.

Inspection of Stations.—All the stations south of latitude 54° N. and west of longitude 2° W. have been visited, and found to be on the whole in a satisfactory condition. Mr. Marriott, in his Report (which will be found in

Appendix II. p. 90), has called attention to the tendency of the authorities at the various Health Resorts to make the observations of their own locality come out as favourable as possible. He also pointed out the desirability that the pattern of sunshine recorder employed should always be stated, as the Jordan Photographic Recorder does not always agree with the Campbell-Stokes burning instrument.

Wind Force Experiments.—Mr. Dines, at the request of the Wind Force Committee, has for some time been carrying on an extensive series of experiments with various forms of anemometers, a grant towards the cost of which having been made by the Meteorological Council, In a report communicated by the Meteorological Council on "Anemometer Comparisons" (*Quarterly Journal*, Vol. XVIII, p. 165) Mr. Dines gave the results of a number of comparisons and described also a new form of Tube Anenometer for recording the pressure and velocity of the wind. This new form of instrument appeared to the Wind Force Committee to be so satisfactory, that they requested Mr. Dines and Mr. Munro to prepare working drawings of a tube anemometer fitted for recording pressure and velocity. An instrument of this pattern has by this time been made for the Meteorological Council.

The results of Mr. Dines's experiments having confirmed the evidence that the use of the factor 3 for the Robinson Anemometer, known as the Kew pattern—the dimensions of which are : distance of centre of cups from centre of axle 24 inches, and diameter of the cups 9 inches—is incorrect, the Council recommend the adoption of the factor 2·1 for that pattern.

As regards the small sized Cup Anemometers, sometimes called Robinson's Anemometers, the Council find that they have been constructed of such various sizes and proportions that no general factor can be assigned. The factor is probably higher than that for the Kew pattern, but may be anything between 2·1 and 3·0. ; and nothing but the verification of each individual pattern can enable its factor to be determined.

Thunderstorm Investigation.—The Council have deemed it inexpedient for the present to continue the Thunderstorm observations which were commenced in 1888.

Donations.—Considerable additions have been made to the library during the year, a list of which will be found in Appendix VI. p. 108. Numerous photographs have been received from different donors, as well as a Casella's mercurial minimum thermometer from the late Dr. Tripe, and a Negretti and Zambra turn-over Hygrometer from Mr. Bayard.

Quarterly Journal.—This publication has contained several interesting papers, amongst which, besides those already mentioned, are "English Climatology 1881-90," by Mr. Bayard, and "The Mean Temperature of the air on each day of the year at the Royal Observatory, Greenwich, on the average of fifty years, 1841-90," by Mr. Ellis.

Meteorological Record.—This publication, which for some time has been in arrear, has now been published more up to recent date, six quarterly parts having been issued during the year. The delay was occasioned by the Council wishing to consider, at the end of the decade 1881-90, whether any change should be made in the method in which the observations made by the

Fellows of the Society are published. The Stations Committee appointed in 1891, held numerous meetings and reviewed the whole subject. The Council ultimately decided to continue the work and the publication of the *Meteorological Record* on the same lines as heretofore, with some improvements suggested by the Committee.

Hints to Observers.—A new edition of this useful publication has been issued during the year. This third edition has been thoroughly revised, and is well illustrated.

The New Offices of the Society.—The experience of the new accommodation which has been gained during the year, has shown the very great advantage which has been secured to the Society by the change. The rooms are larger, more airy, and much better lighted than the old ones. They are also much more convenient for Fellows wishing to consult the Library. This increased accommodation naturally involves greater expense for warming, etc., but the Council have reason to hope that the more prominent position of the Offices will attract a larger number of candidates for the Fellowship of the Society.

Fellows.—The changes in the number of Fellows during the year are exhibited in the following table, which shows an increase of five:—

Fellows.	Annual.	Life.	Honorary.	Total.
1891, December 31st ..	403	132	15	550
Since elected	+34	+2	+5	+41
Since compounded	— 4	+4	...	0
Deceased.............. ...	—11	—1	—1	—13
Retired	—19	...	...	—19
Lapsed	— 1	...	...	— 1
Defaulters	— 3	...	...	— 3
1892, December 31st...	399	137	19	555

Deaths.—The Council have to announce with much regret the deaths of twelve Fellows, and of one Honorary Member. The names are:—

Sir George Biddell Airy, K.C.B., M.A., D.C.L., F.R.S.,	elected	Mar. 19, 1862.
George Forster Burder, M.D.	,,	Nov. 28, 1854.
Alfred Carpenter, M.D., J.P., F.R.M.S.	,,	Feb. 20, 1867.
Sir John Coode, M.Inst.C.E., F.G.S.	,,	June 18, 1862.
John William Horace Gray	,,	Nov. 21, 1888.
John Hartnup, F.R A.S.	,,	Dec. 16, 1885.
Charles Henry Holden	,,	Feb. 20, 1878.
Benjamin Loewy, F.R.A.S.	,,	Nov. 18, 1868.
Henry John Marten, M.Inst.C.E.	,,	Feb. 18, 1880.
William Royston Pike, M.R.C.S.	,,	Jan. 18, 1888.
Prof. Dominico Ragona (Honorary Member)	,,	Apr. 17, 1878.
Maj.-Gen. Fredk. Smith Stanton, R.E., Assoc.Inst.C.E.	,,	Dec. 18, 1889.
John William Tripe, M.D., M.R.C.P.Ed.	,,	May 17, 1856.

APPEN-

STATEMENT OF RECEIPTS AND EXPENDITURE

Receipts.

	£	s.	d.	£	s.	d.
Balance from 1891				224	4	10
Subscriptions for 1892	679	2	0			
Do. former years	37	0	0			
Do. paid in advance	30	2	0			
Life Compositions	126	0	0			
Entrance Fees	40	0	0			
				912	4	0
Meteorological Office—Copies of Returns	113	14	2			
Do. Grant towards Inspection Expenses	25	0	0			
Do. " " Illustrations	5	18	0			
				144	12	2
Dividends on Stock (including £38 12s. 10d. from the New Premises Fund)				105	19	8
Sale of Publications				37	10	2
Sale of £250 2¾ % Consols				242	10	6
				1667	1	4
Balance due to the Assistant-Secretary				2	5	6
				£1669	6	10

DIX I.

FOR THE YEAR ENDING DECEMBER 31st, 1892.

Payments.

	£	s.	d.	£	s.	d.
Journal, &c.:—						
Printing Nos. 81 to 84	122	7	3			
Illustrations (including £3 1s. 6d. balance of the Grant for Thunderstorm Inquiry)	54	1	6			
Authors' Copies	25	11	0			
Meteorological Record, Nos. 41 to 46	67	7	6			
Registrar-General's Reports	8	8	0			
				277	15	3
Printing, &c.:—						
General Printing	28	5	0			
Stationery	18	12	10			
Books and Bookbinding	31	14	9			
Hints, By-Laws, and List of Fellows	48	12	0			
Forms	13	5	0			
				140	9	7
Office Expenses:—						
Salaries	432	13	5			
Rent and Housekeeper	141	14	0			
Furniture, Repairs, Coals, &c.	11	10	4			
Postage	72	11	11			
Petty Expenses	18	12	3			
Refreshments at Meetings	14	8	2			
Exhibition of Instruments	6	7	2			
Subscriptions overpaid returned	4	0	0			
				701	17	3
Observations:—						
Inspection of Stations	51	5	9			
Observers at Old Street and Seathwaite	7	2	0			
Instruments	1	7	0			
				59	14	9
Stock:—						
Purchase of L. and N. W. R. Ordinary Stock, £2)0				346	18	8
				1526	15	6
Balance:—						
At Bank of England				142	11	4
				£1669	6	10

Examined and compared with the Vouchers, and found correct,

J. S. HARDING,
H. SOWERBY WALLIS, } *Auditors.*

January 12th, 1893.

APPEN-

ASSETS AND LIABILITIES

Liabilities.

	£ s. d.	£ s. d.
To Subscriptions paid in advance	30 2 0	
,, Balance due to the Assistant Secretary	2 5 6	
		32 7 6
,, Excess[1] of Assets over Liabilities		2669 13 1
		£2702 0 7

[1] This excess is exclusive of the value of the Library and Stock of Publications.

NEW PREMISES FUND,

	£ s. d.
Amount paid to the Society's Funds towards the increased rent of the New Premises	38 12 10
Amount invested in purchase of £53 3s. 2d. South Australian 3½ per cent. inscribed Stock....................................	50 14 0
	£89 6 10

DIX I.—Continued.

ON JANUARY 1st, 1893.

ASSETS.

	£ s. d.	£ s. d.
By Investment in M. S. and L. R. 4½ per cent. Debenture Stock, £800 at 145	1160 0 0	
,, Investment in N. S. W. 4 per cent. Inscribed Stock, £654 18s. at 110	720 7 9	
,, Investment in L. & N. W. R. Ordinary Stock, £200 at 172¾	345 10 0	
		2225 17 9
,, Subscriptions unpaid, estimated at	36 0 0	
,, Entrance Fees unpaid	2 0 0	
,, Interest due on Stock	31 19 11	
		69 19 11
,, Furniture, Fittings, &c.	192 9 10	
,, Instruments	71 1 9	
		263 11 7
,, Cash in hands of Bank of England		142 11 4
		£2702 0 7

J. S. HARDING, H. SOWERBY WALLIS, } *Auditors.*
WILLIAM MARRIOTT, *Assistant Secretary.*

January 12th, 1893.

DECEMBER 31st, 1892.

	£ s. d
Contributions of Fellows	50 14 0
Interest received on investment as below	38 12 10
	£89 6 10

J. S. HARDING, H. SOWERBY WALLIS, } *Auditors.*
WILLIAM MARRIOTT, *Assistant Secretary.*

January 12th, 1893.

NOTE.—The Society holds on account of this Fund £1185 11s. 4d. South Australian 3½ per cent. inscribed Stock.

APPENDIX II.

Inspection of Stations, 1892.

The stations inspected during the present year have been those south of Latitude 54° N, and west of Longitude 2° W; and also three new stations.

As a whole, the stations were in a satisfactory condition, and the instruments in good order. The changes in the zeros of the thermometers were not very numerous, nor were they large in amount.

At several stations I recommended a rearrangement of the thermometers in the screen, so that they might be mounted according to the instructions given in the *Hints to Observers.* This has necessitated the top of the wooden frame carrying the dry and wet bulbs being cut off in some cases, so that the ordinarily readable part of their scales might be above the maximum thermometer. All maximum and minimum thermometers should be provided with suspenders having a slot as well as a hole, so that they may fit tightly to the screws, and not be shaken by the wind. At two stations I found that, owing to the vibration of the thermometers, the maximum readings in windy weather had been too high.

The Blizzard of last year has shown how uncertain the measurement of snow may be in windy weather, especially when the gauge has only a shallow funnel. It is very desirable that Snowdon or deep rimmed gauges only should be used. This has been recommended where possible, and three observers have since procured new Snowdon rain gauges.

Observers do not always notice the growth of plants, shrubs, and trees, which may affect the exposure of the rain gauge or thermometers. At one place turnips were growing so close to the rain gauge as almost to cover it up. At another a row of scarlet runners was growing only a few feet from the rain gauge and thermometers.

At a few stations the observations have been left entirely to subordinates, the recognised authority having apparently exercised little or no supervision over them. The consequence has been that the observations have been carelessly taken, and the instruments not properly attended to. At one station where the observations had been for a long time very unsatisfactory, and I could not get any information by correspondence, the borough surveyor told me that he had reason to believe that the clerk whose duty it was to take the observations had at times never been near the instruments. I am glad to say that this state of affairs no longer exists, and that the observations are now taken with some amount of supervision.

As the thermometer screen and rain gauge at Ilfracombe are not of the orthodox pattern, I called upon the manager of the Hotel and pointed out to him the desirability of a Stevenson screen and a Snowdon rain gauge being obtained and placed over grass, so that no question could be raised as to the quality of the observations, and that they might be strictly comparable with those at other stations. I am glad to state that the Directors have since decided to carry out this recommendation.

I called upon the Town Clerk at Bournemouth with the view of inducing

the Town Council to furnish regular climatological observations to the Society. I found that an admirable station had been equipped in the cemetery, and that observations had been regularly made since the beginning of the year. The Town Council, however, were of opinion that the recorded temperatures are unfavourable to Bournemouth, and they therefore did not consider it desirable at present to forward the readings to the Society for publication. I do not share this opinion, as I believe the observations are representative of the district. The people of Bournemouth have nothing to fear from the publication of reliable observations.

The spirit of endeavouring to make the observations come out as favourable as possible is very prevalent at so called health resorts. I always, however, refuse to be a party to any of these arrangements. It is now the fashion to try to show that various health resorts have a large amount of sunshine. At some places the Campbell-Stokes burning recorder is employed, while at others the Jordan photographic recorder is used. Those places which have the latter instrument naturally report the greatest amount of sunshine. As both patterns of recorders have been in use side by side at Torquay for several months the following results may be interesting:—

		Campbell-Stokes.	Jordan.	Excess of Jordan over Campbell-Stokes.	
		hrs.	hrs.	hrs.	per cent.
1891	May	161·1	193·3	32·2	20
	June	161·9	201·4	39·5	24
	July	184·4	219·2	34·8	19
	August	119·5	145·3	25·8	22
	September	128·6	164·8	36·2	28
	October	94·8	117·6	22·8	24
	November	55·3	64·3	9·0	16
	December	40·0	57·4	17·4	44
1892	January	65·2	79·0	13·8	21
	February	69·8	73·6	3·8	5
	March	119·8	161·3	41·5	35
	April	213·5	251·8	38·3	18
	May	186·8	221·5	34·7	19
	June	203·7	231·0	27·3	13
	July	191·5	222·3	30·8	16
	August	172·3	205·5	33·2	19
	September	94·1	123·8	29·7	32

I would strongly urge that when any sunshine values are quoted, the pattern of recorder employed should always be stated.

WILLIAM MARRIOTT.

October 19th, 1892.

NOTES ON THE STATIONS.

ABERYSTWITH, *September 9th.*—No change had taken place in the thermometers. I recommend a rearrangement of the thermometers in the screen,

as they were not conveniently placed for getting a good light on the scales. As the enclosure is not very large, the rain gauge is somewhat sheltered by the stand for the sunshine recorder. The railings, which are rather high, may also possibly interfere with the sun's rays in the winter and the early morning and late evening. I suggested that another rain gauge should be obtained and placed in Dr. Davies's garden in the town.

ADDINGTON HILL, *September 16th.*—The instruments are placed in a large railed-off enclosure on the top of the covered-over reservoir of the Croydon Corporation, and are very well exposed. The situation is very open. The maximum and minimum thermometers were liable to be shaken by the wind, as the brass plates for hanging them had circular holes and no slot. I endeavoured to prevent vibration by making the screws tighter.

APPLEBY, *July 19th.*—The instruments are placed in a garden, on sloping ground, on the west bank of the river Eden. The thermometers, which had not been verified, required re-adjusting in the screen. The rain gauge, which had a shallow funnel, was placed in a drain pipe. I recommended that a Snowdon gauge should be obtained, as the snowfall is sometimes very heavy. Instruction was given to the observer as to the method of reading the thermometers, and of taking the observations in general.

ASHBURTON, *August 23rd.*—As the posts of the thermometer screen were very weak, I recommended that they should be renewed and the screen painted. The rain gauge had been placed temporarily on the bank near the house. As this exposure was not very satisfactory, I suggested that the gauge should be removed to its former site in the field.

BABBACOMBE, *August 22nd.*—This station was in good order. A tree on the east-north-east had been lopped a short time previously, and the exposure was consequently a little more open.

BLACKPOOL, *July 18th.*—The observations from this station had for some time past been very unsatisfactory. In conversation with Mr. Wolstenholme I found that he had reason to believe that the clerk whose duty it had been to take the observations had at times never been near the instruments, and that the observations were consequently worthless. Fresh arrangements had been made, and were now working satisfactorily. The present assistant, who makes the observations and appears to take an interest in them, required instruction. The muslin and cotton on the wet bulb had not been changed for many months, and consequently were not in working order. The thermometer screen required painting. Turnips had been allowed to grow up round the rain gauge, and to shelter it greatly. I had the tops of these cut off, and requested the observer in future to keep the rain gauge quite clear. The sunshine recorder, which is on the end of the pier, seemed to be somewhat out of focus on the afternoon side, and did not apparently register all the late evening sunshine.

BOLTON, *July 18th.*—This station was in good order. On comparing the thermometers it was found that the maximum had gone down 0°·4.

BRAMPFORD SPEKE, *August 18th.*—No change had taken place in the thermometers. I recommended that a large branch of an apple tree to the south-

west of the thermometer screen should be cut off. I found that Miss Gamlen had sometimes re-set the minimum thermometer during the day. I requested that for the future the instruments should only be set at 9 a.m., so that the record for the full twenty-four hours might be obtained. The rain gauge is in an open situation in the kitchen garden. The tree on the lawn in the front of the house close to the old rain gauges had been cut down.

Bude, *August 27th.*—No change had taken place in the instruments at this station. As the bulbs of the dry and wet thermometers were simply let in the wood—that is, the wood was cut out for the bulbs—I cut off the piece of board above the bulbs, so that they are now quite free. It is possible that this wood may have prevented the circulation of the air and so have caused the thermometers to indicate a higher humidity than they would have done under free conditions.

Burghill, *September 5th.*—The thermometer screen was moved to a more open spot on the lawn soon after the previous inspection. No change had taken place in the thermometers, but at the time of my visit the wet bulb was dry, the water receptacle being empty.

Buxton, *July 16th*—The rain gauge measuring glass had been broken during the winter and a new one obtained from Liverpool. As this was not correct, I recommended that a new measuring glass be obtained and sent to me for verification. Mr. Beck informed me that he would shortly be leaving Buxton, but that the observations would be continued by his successor Mr. Bowden.

Carmarthen, *September 8th.*—I recommended that holes be made in the sides and at the top and bottom of the thermometer screen, in order to ensure better circulation of air. On comparing the thermometers it was found that the maximum had risen $0^{\circ}\cdot2$ and the minimum gone down $0^{\circ}\cdot2$. The anemometer is to be removed, as it is too close to the rain gauge.

Castle Hill, *September 1st.*—The instruments were in good order and were in the same position as at the last inspection.

Cheltenham, *September 3rd.*—On comparing the thermometers it was found that the dry bulb had gone up $0^{\circ}\cdot1$. The water receptacle required a cover with a hole in it for the conducting thread to go through. As the rain gauges appeared to be sheltered by trees, I suggested that one of the gauges should be moved further to the south.

Churchstoke, *September 9th.*—The instruments were clean and in good order. The sunshine recorder is mounted on a pedestal near the thermometer screen. A better exposure for it would no doubt be obtained on the tower, as in its present position the trees on the south-west and west may possibly intercept the late afternoon sun.

Cullompton, *August 18th.*—This station was in good order. The sunshine recorder is mounted on the top of an iron lamp post, the glass ball being 15 ft. 2 ins. above the ground; some trees on the west and west-north-west may possibly cut off a little of the late evening sunshine.

Exeter, *August 20th.*—I found that the enclosure was still covered with cinders as at the last inspection. The observer, however, undertook to have

them removed and grass laid down. I learnt that the observations had for some time been taken at 10 a.m. instead of at 9 a.m., local time. I impressed upon the observer the necessity of taking the observations strictly in accordance with the regulations of the Society, so that the observations may be comparable with those at other stations. On comparing the thermometers it was found that the wet bulb had gone up 0°·1.

FALMOUTH, *August 26th.*—The thermometers were all correct. I recommended that a glass water receptacle with a zinc cap be used for the wet bulb, and also that the rain gauge be so adjusted that the funnel could be put on more easily.

ILFRACOMBE, *August 30th.*—There was no change in the instruments at this station since the last inspection. In the discussion on Mr. Bayard's Paper, "English Climatology 1881-90," at the meeting on June 15th, 1892, some exception was taken to the Ilfracombe observations, as the thermometers were not mounted in a Stevenson Screen, but were placed in a large summer house sort of erection with a pyramidal roof. It was thought that the high winter temperatures were not natural, but were really due to the method of exposure. Although the screen has not been of the orthodox pattern, I have always believed that the temperature observations taken in it have been fairly comparable with those in a Stevenson Screen. The high winter mean temperature is no doubt due to the sheltered position of the town landwards and seawards. In order that there might be no further ground for criticism, I called upon the manager of the Ilfracombe Hotel, and pointed out to him the desirability of a Stevenson Screen and Snowdon rain gauge being obtained and placed over grass, so that no question could be raised as to the quality of the observations, and that they might be strictly comparable with those from the other stations of the Society. I selected a site for the thermometer screen and rain gauge on the lawn to the east of the hotel, and to the south of the old screen. The directors have since fully carried out this recommendation. The results from the thermometers in the old and new screens agree in a most remarkable manner.

LLANDUDNO, *July 14th.*—Dr. Nicol had been ill for some time and had consequently not been able to supervise the observations. I found the deputy in charge and gave him instructions in the method of taking the observations. The minimum thermometer had 0°·5 of spirit at the top of the tube. The rain gauge was only 7 ins. above the ground; this I raised and fixed it at 1 ft.. The sunshine recorder is now placed on the pier, and is in charge of the pier master.

MACCLESFIELD, *July 15th.*—The thermometer screen required painting. The minimum had gone down 0°·3, which was probably due to a little spirit at the end of the tube, which could not be shaken down.

MALVERN, *September 5th.*—The instruments were in the same position as at the last inspection. The screen required painting, and a new receptacle for the wet bulb was also necessary.

NORTHWICH, *July 15th.*—The instruments are placed in the garden of Highfield House, on high ground between 60 and 70 ft. above the river

Weaver, and south of it. The thermometers required re-arranging in the screen. The minimum read 0°·8 too high, which was probably owing to spirit up the tube. The screen required painting. The rain gauge funnel, which was 3 ft. 3 ins. above the ground, was fitted to a lid on the cylinder, which had a handle and a spout, and looked like a coffee pot. As the lid had no flange outside, rain must at times have got inside and so increased the amount of rainfall. I recommended that a Snowdon gauge be obtained and placed 1 ft. above the ground. I found that the corrections for the thermometers had been applied as whole degrees instead of tenths of a degree! I gave the deputy observers full instructions in the method of taking the readings and reducing the observations.

Plymouth, *August 24th.*—This station was organised by Mr. H. N. Dickson in 1891, the thermometer screen and rain gauge being placed in the public lavatory garden at the east end of the Hoe. The exposure was good. The sunshine recorder had been placed on the roof of the Marine Biological Institute. As Mr. Dickson had left the Institute in July, I found that the instruments had been dismounted and the observations discontinued. I saw Mr. Calderwood, the director, who informed me that there was not much prospect of the observations being resumed.

Princetown, *August 24th.*—The returns from this station to the Society had lapsed since October 1891, owing to the removal of Dr. Stone and to the inability of obtaining some one to take charge of the observations. I called on the Governor of the prison and with him saw the dispenser, who agreed to take readings at 9 a.m. It is practically impossible to get 9 p.m. observations taken, as the officials live out of the prison and have to put on uniform before going into the prison.

Ross, *September 6th.*—The tube of the maximum thermometer had shifted, so that the divisions on the tube did not correspond with those on the scale. This I readjusted. As the thermometer screen was very much confined by trees and shrubs which had grown up all round, I recommended that it be removed to a more open situation near the rain gauge.

Rousdon, *August 19th.*—This station was in good order. On comparing the thermometers it was found that the dry bulb had gone up 0°·1. The Richard self-recording rain gauge works very well, and is mounted on a concrete foundation to prevent vibration. Mr. Peek contemplates having a thermograph mounted in a second Stevenson screen.

Sheerness, *September 23rd.*—The instruments are placed on the lawn near the pumping engine house and are well placed. The trees close by, however, require to be kept low. I recommended that the thermometers be re-arranged in the screen and that a cover be provided for the water receptacle. The grass minimum had 3°·2 of spirit at the top of the tube. The Jordan twin Sunshine Recorder is placed on the corner of the water tower. A chimney on the west and a pipe on the east intercept the sun's rays during part of the year. No loss of sunshine, however, occurs, as due allowance is made for this.

Sidmouth, *August 17th.*—This station was in good order. The Jordan

twin Sunshine Recorder belonging to Dr. Oliver is mounted on the tower of the Knowle Hotel, and is very well exposed. In Dr. Oliver's absence his coachman changes the papers and fixes them.

STOWELL, *August 17th.*—There was no change in the thermometers. I recommended that the rain gauge, which was only 5 ins. above the ground, should be raised to 1 ft. As the exposure of the sunshine recorder is not very good, the records have been discontinued.

TAUNTON, *September 2nd.*—The thermometer screen, which is a large home-made one, is placed in a kitchen garden on the east side of South Street. The exposure is fair but somewhat confined. The rain gauge is in a garden in Trinity Terrace, not far from the other instruments. On comparing the thermometers it was found that the minimum and the grass minimum had both gone down 0°·2.

TEIGNMOUTH, *August 20th.*—The thermometers are in the same position as at the last inspection. The rain gauge, however, has been removed from Mr. Harris's garden on the Dene to Dr. Lake's garden, and is now near the thermometer screen. A tree in the Bitton grounds has been removed, so the exposure is not quite so confined as formerly. On comparing the thermometers it was found that the maximum had gone up 0°·2 and the wet bulb 0°·1.

TORQUAY, *August 22nd.*—The instruments are placed on Cary Green, an enclosed open space between the Strand and the Warbury Hill. The exposure is very good. The instruments belong to the Local Board, and the observations are taken by Mr. C. Shapley. Two sunshine recorders, viz. the Campbell-Stokes and the Jordan, are mounted on Chapel Hill, 286 feet above sea-level, and are under the control of Mr. A. Chandler.

WESTON-SUPER-MARE, *September 2nd.*—The thermometer screen required painting. On comparing the thermometers it was found that the minimum had gone down 0°·4. A new receptacle was recommended for the wet bulb.

WEYMOUTH, *August 16th.*—No change had taken place in the thermometers. The screen required painting. Scarlet runners had been planted and allowed to grow up close to the rain gauge. I requested that these should be removed at once. The observations are now taken by Mr. Sivyer, a coast guardman.

APPENDIX III.

Subscriptions promised towards the New Premises Fund.

THIRD LIST.

	£	s.	d.
Amount already promised	1,168	3	6
Prof. Cleveland Abbe	2	0	0
Dr. A. Buchan, F.R.S.E.	3	3	0
Mr. W. Greatheed	1	0	0
Mr. C. E. Harris	1	1	0
Mr. E. L. Oxenham	1	0	0
	£1,176	7	6

APPENDIX IV.

OBITUARY NOTICES.

Sir G. B. Airy.—The Journal of the Royal Meteorological Society is hardly the place to look for a notice of Sir George Biddell Airy, inasmuch as his prolonged and unusually active life was spent in researches connected with branches of science other than that followed by this Society.

To give some idea of the marvellous fertility of his brain, it may be stated that the *Royal Society Catalogue of Scientific Papers*, which closed with 1883, nine years before he died, contained no less than 242 titles of papers from his pen, a total surpassed by only a very few among the long list of names which figure in that work.

The reader must have recourse to the *Monthly Notices* of the Royal Astronomical Society and the *Proceedings* of the Royal Society to gain a fuller account of his many-sided scientific activity.

To meteorology proper his contributions were few. He contributed to the *Proceedings* of this Society a brief note "On the Theory of Vapour Pressure," which appeared in Vol. I. p. 365, and a paper "On the determination of heights from barometer readings," consisting of a table for the graduation of aneroids, which will be found in Vol. III. p. 406. In the *Philosophical Transactions* for 1851 he printed a paper "On the relation of the direction of the wind to the age of the moon, as inferred from observations made at the Royal Observatory, Greenwich, from November 1840 to December 1847." The very last of his papers, given in Vol. IX. of the Royal Society's *Catalogue of Scientific Papers*, is entitled "Monthly means of the highest and lowest diurnal temperatures of the water of the Thames, and comparison with the corresponding temperatures of the air at Greenwich," and it appeared in Vol. XXXIV. of the *Proceedings* of the Royal Society.

Sir George was born at Alnwick, July 27th, 1801, and he died at Greenwich, January 2nd, 1892, having retained his faculties to the last. He was elected into this Society March 19th, 1862.

The principal service which he rendered to our science was the organisation of the Magnetical and Meteorological Department of the Royal Observatory soon after his appointment as Astronomer Royal in 1836. It is understood that many of the theoretical discussions appearing in the successive volumes of Results were from his pen.

He received the honour of K.C.B. in 1872, and he served the office of President of the Royal Society from 1871 to 1873. He was a Fellow of the Royal Society for no less than 56 years, from the time of his appointment as Astronomer Royal.

George Forster Burder, M.D., was the son of the Rev. John Burder, a Nonconformist minister, and was born at Stroud in 1824. He received his medical education at University College, London; in 1850 he obtained the diploma of M.R.C.S.; in 1851 that of L.S.A. and the degree of M.D. of

King's College, Aberdeen; in 1859 he was made a Member and in 1875 a Fellow of the Royal College of Physicians.

He settled in practice in Clifton, and in 1856 was appointed physician to the Bristol General Hospital, a post which he held until 1883, when, after twenty-seven years of active service, he was made consulting physician to the hospital. For twenty-three years he held the Lectureship on Materia Medica and Therapeutics at the Bristol Medical School, and for the last seventeen years of this period acted as honorary secretary to the school; both these positions he resigned in 1879.

Dr. Burder was President of the Bristol Medico-Chirurgical Society for the session 1884-85, and of the Bath and Bristol Branch of the British Medical Association for the year 1887-88, and both of his presidential addresses treated in a masterly manner certain of the problems connected with the "germ theory" of disease, to which he was an early convert.

Dr. Burder was an able, clear-sighted, scientific physician, and an excellent therapeutist, and enjoyed the complete confidence of his patients. He had also a high reputation in scientific subjects outside his own profession. He was widely known as a distinguished meteorologist, and was the regular contributor of valuable communications on the meteorology of the district. Only two days before his death he read before the Bristol Naturalists Society an able paper on Rainfall and Floods.

A thoroughly clear, logical thinker, and endowed with sound common sense, Dr. Burder possessed as a speaker the rare power of expressing his thoughts in forcible, well-chosen language. As a man he was very highly esteemed for his signal uprightness and integrity of character. Kindly and genial in his manner and a favourite with all, by all those who knew him best he was beloved in no common degree.

For some years Dr. Burder had suffered from anginal symptoms, which had increased in severity of late, and on February 6th, 1892, he died suddenly from syncope.

He was elected a Fellow of this Society on November 28th, 1854.

Alfred Carpenter, M.D., was born at Rothwell, Northamptonshire, May 28th, 1825, his father being a medical practitioner of that place, to whom, after finishing his general education at Moulton Grammar School, in Lincolnshire, he was apprenticed at the age of 14. Two years later he became a pupil of Mr. Percival, at the Northampton Infirmary, where he remained for three years, returning at the expiration of that period to Rothwell to assist his father. Next he became assistant to Mr. J. Syer Bristowe, at Camberwell, and in 1847 he entered St. Thomas's Hospital. He was the first student who gained a scholarship at that institution, and he also held in succession the posts of Resident Accoucheur and House Surgeon.

He took the M.R.C.S. and L.S.A. in 1851, and in 1852 became associated in practice with Dr. Westall, of Croydon, in which town he continued to reside. Dr. Westall having retired in 1860, Mr. Carpenter entered into partnership first with Mr. Whitling, and afterwards with Dr. H. T.

Lanchester. Mr. Carpenter graduated M.B. at the University of London in 1855, and M.D. in 1859. In 1860 he became medical attendant upon Dr. Sumner, Archbishop of Canterbury, and he was afterwards medical adviser to Archbishops Longley and Tait.

In 1859 Dr. Carpenter was appointed a member of the Croydon Local Board of Health, on which he continued to serve, acting occasionally as chairman, until his election as President of the Council of the British Medical Association in 1879. His connection with the Board of Health was fruitful of results in the interests of sanitary science. He was chiefly instrumental in the extension and successful working of the Croydon Sewage Farm, and the Public Baths at Croydon were likewise established by him. To his exertions also was due the ventilation of the sewers. In 1870 he was appointed a magistrate for Surrey.

Dr. Carpenter filled numerous local offices of importance, having been President of the Croydon Literary and Scientific Institute, of the Croydon School of Art, of the Microscopical Club and Natural History Society, and of the Croydon Temperance Society. He also took an active part in the establishment of the Croydon Cottage Hospital and of the Croydon Provident Dispensary.

In 1878 he was Orator of the Medical Society of London, and took for the subject of his discourse "Alcoholic Drinks." He was also a member of the Health Committee of the Social Science Association, and Vice-Chairman of the Council of the Sanitary Institute. He was President of the Health Section at the Croydon Sanitary Congress in 1872, and in December 1881 he presided over the Domestic Health Section at the Brighton Congress. Dr. Carpenter was Examiner in Public Health in the University of London, and a member of the Court of Examiners at the Apothecaries' Company. In 1881 he was nominated a member of the Royal Commission appointed to inquire into the condition of the London hospitals for small-pox and fever cases, and into the means of preventing the spread of infection.

Dr. Carpenter was the author of numerous papers on sanitary science, temperance, etc.

He died at Ventnor on January 27th, 1892, aged 66 years.

He was elected a Fellow of this Society on February 20th, 1867.

Sir John Coode was born at Bodmin in 1816, and received his education at the Bodmin Grammar School. He early in life chose the profession of civil engineer, and became a pupil of Mr. J. M. Rendel, who entrusted him with responsibilities in connection with the carrying out of many public works. For seven years he was employed on the Great Western Railway works. The experience he had thus early gained, is evidenced by his having been chosen in 1847, when he was but 31 years of age, as resident engineer of such an important work as the National Harbour and Breakwater at Portland, Mr. Rendel being the engineer in chief. The work, notwithstanding many great difficulties, progressed satisfactorily, and when after nine years operations Mr. Rendel died, Mr. Coode was appointed engineer in

chief in his stead. This was in 1856, and on the completion of the great work in 1872, he recived the honour of Knighthood.

Sir John Coode devoted himself almost exclusively to the marine branch of his profession, and there are few important harbours around our coasts with which he has not been connected in some way, either in the actual design and execution of works, or in references at one time or another from harbour authorities or Government departments.

Sir John Coode also rendered great service to the Colonies in developing their harbour works, and making their maritime trade possible. At the request of the Government he made a tour of Australasia, and visited the Cape Colony, New Zealand, the Straits Settlement, India, Ceylon, and the American Continent; and when he delivered his presidential address to the Institution of Civil Engineers, he mentioned the fact that visits to distant colonies had involved journeyings of more than 75,000 miles, and he on that occasion offered the result of his close examination of such features as were most interesting from the standpoint of a civil engineer.

His very extensive work to the Colonies was recognised by his elevation to the rank of K.C.M.G. He joined the Institution of Civil Engineers in 1849, and was elected President in 1889.

Sir John Coode was an upright and honourable man, greatly respected by all with whom he came in contact, just in all his dealings with his clients and his professional brethren, and he will long be remembered as one who tried at all times to uphold the dignity and nobility of the profession of which he was an esteemed member.

He died at Brighton on March 2nd, 1892, after several months' illness.

He was elected a Fellow of this Society on June 18th, 1862.

John Hartnup was born at Somerset House, in the apartments of the Royal Astronomical Society, in 1841, when his father held the position of Assistant Secretary. In 1843 his father removed to Liverpool, having been appointed Astronomer to the Mersey Docks and Harbour Board, and the whole of Mr. Hartnup's life may be said to have been passed upon the banks of the Mersey. He was educated at the Royal Institution School, Liverpool, and at a private academy at Chester, and his scientific training seems to have been effected under his father's sole and careful supervision. He became assistant in the Liverpool Observatory in 1863, shortly before the Observatory was removed from the Waterloo Dock to its present position at Bidston, and there he gave unremitting attention to those many experiments on chronometer rates with which his father's name has been so long connected, and which have proved of such signal service to the mercantile marine.

On the death of his father, in 1885, Mr. Hartnup succeeded him as director of the Observatory and so remained until his death. His most valuable contributions to science have been his papers on chronometer management, and his reputation must rest on these. He gave effective support and assistance to the Liverpool Astronomical Society, holding for

some time the position of Vice-President, and other scientific societies in Liverpool found in him a warm and cordial supporter.

Mr. Hartnup died on April 21st, 1892. His death was the result of an accident. Having gone to the roof of the Observatory to inspect the anemometer, it appears that he was seized with an attack of giddiness, to which he was at times subject, and falling over the low parapet to the ground, was killed instantly.

He was elected a Fellow of this Society on December 16th, 1885.

Henry John Marten, M.Inst.C.E., was born on February 3rd, 1827. He was the son of Robert Giles Marten, of Plaistow, and grandson of Robert Humphrey Marten, a London merchant of the same place, who was a Director of the East London and of the Kent Water Companies, and Deputy Chairman of one of the large London Dock Companies. He was educated at Mill Hill School, and at the age of 16 was articled to Mr. Wicksteed, the Engineer of the East London Water Works, who at that time enjoyed a large private practice.

After some training in Mr. Wicksteed's office, he was sent by that gentleman to Hull, and thence to Wolverhampton to superintend the construction of the water works there. At their completion young Mr. Marten was appointed Resident Engineer with a right to take private practice. He continued to act in this capacity until he was about 28 years old, and in the interval he carried out many important water works, amongst others being large extensions of the Wolverhampton Water Works, including almost the first covered reservoirs which were constructed in this country. Also water works for the towns of Bridgnorth and Wellington (Salop) and for the Stourbridge district.

In association with the late Mr. McClean he constructed the earlier works of the South Staffordshire Water Works Company, which now supply upwards of 400,000 people. He also converted the service at Wolverhampton from an intermittent to a constant one, and he may be regarded as having been one of the pioneers of the system of constant supply, his experiments at Wolverhampton having conclusively proved its practicability, which had previously been in doubt.

At the age of 27 Mr. Marten married the daughter of the late Mr. E. B. Dimmack, a large ironmaster in Staffordshire and South Wales, and shortly afterwards he temporarily retired from the active practice of his profession, having entered into partnership with his father-in-law, and for the next twenty years he did little professional work beyond occasionally giving evidence before Parliamentary Committees in explanation of technical questions connected with the iron and coal industries. In 1875, however, on the death of his father-in-law, and the winding up of the undertakings in which they had been jointly concerned, Mr. Marten returned to active professional life, and from that time to his death he enjoyed an extensive practice.

He carried out, amongst other important works, the Tamworth District Water Works, the West Gloucestershire Water Works, the Dudley Sewerage

Works, the Tipton Sewerage Works, and (in partnership with his son, Mr. E. D. Marten) the Tettenhall Sewerage Works.

Mr. Marten was Engineer to the Severn Commissioners, and at the date of his death was carrying out large works for the improvement of the navigation of that river.

He was also Engineer to the Staffordshire and Worcestershire Canal Company, an Engineering Inspector under the Board of Agriculture, and one of the three Statutory Arbitrators under the South Staffordshire Mines Drainage Acts.

He had a large practice as a Consulting Engineer, numbering amongst other clients in this respect the Corporations of Walsall, West Bromwich and Wolverhampton, the York Water Company, and the Guardians of the Seisdon Union.

In Parliamentary work and kindred matters Mr. Marten was well known as a man of sound judgment and as a clear headed witness, and was usually engaged upon one side or the other in all the great water works or navigation matters before the Parliamentary Committees.

In the year 1891, at the instance of the Conservators of the River Thames, he and Mr. Henry Rofe, M.Inst.C.E., prepared a joint report, accompanied by an elaborate set of plans, upon the feasibility of constructing storage reservoirs in the upper Thames Valley with a view to the improvement of the water supply of the Metropolis, and a few weeks before his death he gave evidence in support of this Report before the Royal Commission upon Metropolis Water Supply which has recently been sitting.

Mr. Marten was taken seriously ill in the early part of 1892, but after travelling on the Continent for some months he returned to England apparently much restored. It is probable, however, that he never really rallied, as he was seized with paralysis on October 28th, after which he never spoke again, and died, after a brief and apparently painless illness, on November 3rd, in the 66th year of his age.

Mr. Marten, whose first wife died in 1862, was married in 1880 to the widow of the late Mr. William Pilkington, J.P., of Blackburn.

He resided and had an office at the Birches, a country house about four miles from Wolverhampton. He had also for many years occupied an office and set of residential chambers at Storey's Gate, Westminster.

He was elected a Fellow of this Society on February 18th, 1880, and at the time of his death was a Member of Council. He was also a Member of the Institution of Civil Engineers, and a Fellow of the Geological Society.

Prof. Domenico Ragona was born at Palermo, on January 20th, 1820, and was the son of Paolo Ragona, a Colonel of Artillery, and of Rosalia Scinà, sister of the celebrated Sicilian physicist, Monsignor Domenico Scinà, who undertook his education. He studied in the Royal University of Palermo, where, whilst still young, he obtained the post of Assistant Professor of Physics, and later that of Assistant at the Royal Astronomical Observatory. Subsequently, having taken part in the important work of the triangulation

of the Province of Palermo, he was nominated titular Professor of Astronomy at that University and Director of the Royal Observatory. At the expense of the State he completed his astronomical studies, first in Berlin, under Enke, and then in Bonn, under Argelander.

In the meanwhile he visited many Observatories of Europe, and made acquaintance with several celebrated scientists, among them von Humboldt. He was then still occupied with the construction of an equatorial with an aperture of nine inches in diameter, which he entrusted to Merz, of Munich, where it is still in the Observatory, and with the construction of a great meridian circle, which was carried out at Berlin by Pistor and Martin.

When the ancient régime (the Bourbons) came to an end in 1860, Ragona gave up the direction of the Observatory of Palermo, and in 1863 was appointed Director of the Royal Observatory of Modena, which post he held till his death.

To mention the many scientific works written by this hard working man would exceed the limits of this notice, but it will suffice to say that they fill fourteen large quarto and octavo volumes.

He occupied himself much with Meteorology, and especially with that of the Modenese district. Dr. Hellmann, in his Official Report on the state of Meteorology in Europe, says "that in the whole of Italy the only town of which the climate is well known is Modena, and this is due to the labour of Prof. Ragona."

He was a member of many Academies and Societies, and was deservedly honoured with the insignia of various orders of chivalry of the Italian and foreign governments.

Prof. Ragona started a Meteorological Society, which he later united with a Meteorological Society then in existence—for the "Correspondenza Alpino Appennina" had been so transformed—and he was a hard working and energetic member.

He died on February 29th, 1892, deeply regretted by Italian and foreign scientists.

Prof. Ragona was elected an Honorary Member of this Society on April 17th, 1878.

Major-General Frederick Smith Stanton joined the Royal Engineers in 1850, and retired in 1887, having in the 37 years of his active service been engaged in the Indian Mutiny Campaigns and the Bhotan Expedition of 1864.

He died on January 22nd, 1892, in the 60th year of his age.

He was elected a Fellow of this Society on December 18th, 1889.

John William Tripe, M.D., was born in London on February 26th, 1821. He was educated at Merchant Taylors' School, and studied medicine at the London Hospital, where he gained two gold medals. He took his M.D. at St. Andrews in 1846, and became M.R.C.S. of England in 1848, and M.R.C.P. of Edinburgh in 1879.

In 1856, on the passing of Sir Benjamin Hall's Act empowering the several districts of the Metropolis to appoint Medical Officers of Health, Dr. Tripe was elected for Hackney. This office he continued to hold during life. And it may be truly said that no district was better served than Hackney. He threw his soul and his energies into the task of improving the health of the population under his immediate charge. But his good work was far from being circumscribed by the narrow boundaries of a district, and he from the first made sanitary science his more special study. He was one of the distinguished few whose labours justified the Act which created the office, and made public medicine what it is—an integral part of our internal administration. No one more successfully than he worked out the relations of Meteorology and general science to this department of medicine. For thirty-six years Dr. Tripe held office. His annual reports to his vestry were conspicuous for clearness of insight into his duties, and for the faithful, efficient, and temperate manner in which his advice was set forth. The esteem in which he was held by his brother medical officers was declared by electing him President of their Association in 1881.

Prof. Parkes soon discovered Dr. Tripe's worth, and enlisted him in the work of the *British and Foreign Medico-Chirurgical Review*. Under Parkes's editorship Tripe contributed valuable memoirs on "Scarlatinal Dropsy and the Mortality from the Eruptive Fevers;" and, under Dr. Sieveking, he contributed a paper on "The Relative Mortality of Males and Females under Five Years of Age," and one on "Poisoning by Sausages." Sir Edward Sieveking said of him: "I think all his articles would deserve reading at the present day, as they show much research and observation."

But his great merit consisted in throwing the light of the allied science of Meteorology more especially on the problems of hygiene. He early in life joined the Royal Meteorological Society, and the part he played in it was no less honourable to himself than signal in its services to the Society. No one could be associated with him without being charmed with his manner—at once earnest and simple. His gentle wisdom and steadiness of purpose rarely failed to command the warm reception of his proposals. This Society is largely indebted to him for its prosperity; and this debt it has always been ready to acknowledge. He was elected a Fellow in 1856, and served on the Council with only one year's intermission from 1858 to the time of his death. He held the office of President in 1871-72; of Vice-President in 1860-61, 1863-64, 1869-70; and of Secretary in 1865-66, 1868, 1873-1892.

In May 1887 Dr. Tripe was presented with a Silver Tea and Coffee Service, which had been procured by means of contributions from a number of the Fellows in acknowledgment of the many services which he had rendered to the Society during a period of over thirty years. In making the presentation the President (Mr. W. Ellis) said: "Dr. Tripe has always taken an active part in all schemes for rendering the Society more generally useful. He advocated the establishment of Climatological Stations, at which, with small tax to the observer, valuable information is obtained, and it was a suggestion of his that led to the institution of those Annual Exhibitions which have of

late years proved so interesting a feature of the Society's work He also inaugurated the custom of reading at the General Meeting a Presidential Address, and his interest in the relation of Meteorology to mortality and to questions of Health and Disease is well known."

Dr. Tripe contributed several papers to the Society, the most popular of which was that "On the Winter Climate of some English Seaside Health Resorts."[1]

After several months suffering from a painful internal malady, Dr. Tripe passed away on April 7th, 1892.

APPENDIX V.

BOOKS PURCHASED DURING THE YEAR 1892.

ACCOUNTS of extraordinary motions of the waters in several places of North Britain. 8°. (1770.)

AEROSTATION. 8°. (1840.)

ANOTHER COLLECTION of Philosophical Conferences of the French Virtuosi. Rendered into English, by G. Havers and J. Davies. F°. (1665.)

ANTES, J.—Observations on the manners and customs of the Egyptians, the overflowing of the Nile, and its effects. 4°. (1800.)

ARBUTHNOT, J.—An essay concerning the effects of air on human bodies. 8°. (1733.)

BACK (Capt.).—Narrative of the Arctic Land Expedition to the mouth of the Great Fish River, 1833-5. 8°. (1836.)

BAIKIE, R.—Observations on the Neilgherries, including an account of their topography, climate, &c. Edited by W. H. Smoult. 8°. (1834.)

BARKER, W. G.—On the climate of Worthing. 2nd ed. 8°. (1867.)

BARTHOLINI, E.—De Aëre Hafniensi. 8°. (1679.)

BIRD, S. D.—On Australasian Climates. 8°. (1863.)

BOURNEMOUTH.—The Visitors' Guide to Bournemouth and its neighbourhood. With an appendix by T. J. Aitkin, M.D. 2nd ed. 8°. (1842.)

BOYLE, J. A.—A practical medico-historical account of the Western Coast of Africa. 8°. (1831.)

BOYLE (Hon.) R.—The general history of the air. 4°. (1692.)

BRUCE, J.—Travels to discover the source of the Nile, 1768-73. 6 vols. 8°. (1790.)

CORNWALL as a winter resort. 8°. (1889.)

DARWIN, C.—Journal of researches into the natural history and geology of the countries visited during the voyage of H.M.S. *Beagle* round the world. 8°. (1860.)

DAVIS, I. B.—The ancient and modern history of Nice. 8°. (1807.)

DES-CARTES, R.—Principia philosophiæ. 4°. (1656.)

DOMEIER, W.—Observations on the climate, manners, and amusements of Malta. 8°. (1810.)

DUNBAR, W.—Account of the rain at Dunse, in Berwickshire, from 1st Oct. 1768 to 1st Oct. 1769. 8°. (1771.)

——— ——— An account of the depth of rain, and height of the barometer, at Dunse, in Berwickshire, from 1st Oct. 1769 to 1st Oct. 1770. 8°. (1771.)

FALCONER, W.—Remarks on the influence of climate, &c. 4°. (1781.)

FEIJOO, B. G.—Theatro critico universal, o discursos varios en todo genero de materias, para desengaño de errores communes. 3rd ed. 8°. (1729-30.)

FONTANA, N.—Osservazioni intorno alle malattie che attaccano gli Europei ne' climi caldi e nelle lunghe navigazioni fatte nel suo viaggio alle Indie Orientali dell' anno 1776 al 1781. 8°. (1781.)

[1] *Quarterly Journal*, Vol IV. p. 111.

FORRY, S.—The climate of the United States, and its endemic influences. 8°. (1842.)

FRANKLIN, B.—Letter to D. Hume, on the method of securing houses from the effects of Lightning. 8°. (1771.)

GILES, S.—The brewer's meteorological and statistical guide. 8°. (1861.)

GRAND, A. le.—Historia naturæ, variis experimentis et ratiociniis elucidata. 2nd ed. 4°. (1680.)

GREGORY, G.—The Economy of Nature explained and illustrated on the principles of modern philosophy. 3 vols. 2nd ed. 8°. (1798.)

HENNESSY, H.—On the distribution of heat over islands, and especially over the British Isles. 8°. (1858.)

HILLARY, W.—Observations on the changes of the air and the concomitant epidemical diseases, in the island of Barbadoes. 2nd ed. 8°. (1765.)

HOMERSHAM, S. C.—An account of some observations made on the depth of rain which falls in the same localities, at different altitudes, in the hilly districts of Lancashire, Cheshire, and Derbyshire. 8°. (1848.)

HOOPER, G. S.—Observations on the topography, climate, and prevalent diseases, of the Island of Jersey. 8°. (1837.)

HUISH, R.—The last voyages of Capt. Sir John Ross, to the Arctic Regions, in the years 1829-33. 8°. (1836.)

HUMBOLDT, A. von.—Aspects of nature, in different lands, and different climates. Translated by Mrs. Sabine. 2 vols. 8°. (1849.)

JENKINS, B. G.—The British astronomical Weather almanac and chart, 1892. 16°. (1891.)

JOHNSTON, K.—A physical, historical, political, and descriptive Geography. 2nd ed. 8°. (1881.)

JOHNSTONI, J.—Thaumatographia naturalis, in decem classes distincta, in quibus admiranda. 12°. (1732.)

KAMES (Lord).—On evaporation. 8°. (1771.)

KECKERMANO, B.—Systema physicum 3rd ed. 8°. (1612.)

L'ASTRONOMIE. Vol. XI. 1892. 8°. (1892.)

LAWSON, R.—Remarks on the Trade Winds and other currents in the atmosphere at Barbadoes. 8°. (1845.)

LEE, E.—The Watering Places of England. 4th ed 8°. (1859.)

LONDON.—Meteorological Journal kept at the Royal Polytechnic Institution, Regent Street, July 1841 to May 1842 (February wanting). 8°. (1841-2.)

LONDON, METEOROLOGICAL SOCIETY.—Proceedings during the Sessions 1838-9 and 1839-40. 8°.

LONDON, ROYAL SOCIETY.—Report of the Committee of Physics and Meteorology relative to the observations to be made in the Antarctic Expedition. 8°. (1840.)

LONDON, SOCIETY OF ARTS.—Lectures on the results of the Great Exhibition of 1851. 8°. (1852.)

MACFAIT, E.—Observations on thunder and electricity. 8°. (1771.)

——————— Some phenomena observable in foggy weather. 8°. (1771.)

MACKENZIE, [G.]—Manual of the weather for the years 1831 to 1838. 8°. (1830-37.)

——————————Reports of the weather for the years 1839-41. F°. (1838-40.)

MACKINTOSH, W.—General statistical, and commercial report of the province of Australia Felix, 1847. 8°.

MARKHAM, C. A.—The Great Frozen Sea. 8°. (1878.)

MAUDSLAY, A.—Nature's Weather Warnings and natural phenomena. 8°. (1891.)

MAURITIUS, METEOROLOGICAL SOCIETY.—Transactions. Vol. II. 8°. (1855.)

MAYOW, J.—Tractatus quinque medico-physici. 8°. (1674.)

METEOROLOGICAL OBSERVATIONS made at Edinburgh, 1732-35 and 1764-70; Plymouth, 1732-35 and 1745-48; Hawkhill, near Edinburgh, 1764-70; Selkirk, 1769-70; and Minorca, 1745-8. 8°. (1771.)

MEYER, E. J. B.—Versuch einer medicinischen Topographie und Statistik der Haupt-und Residenz-Stadt Dresden. 4°. (1840.)

MILLS, J.—An essay on the Weather. 8°. (1770.)

MISCELLANEA CURIOSO. Being a collection of some of the principal phenomena in Nature. 8°. (1705.)

MONARDUS, N.—The boke which treateth of the snow, and of the properties and vertues thereof, &c. 4°. (1580.)

MOURAO-PITTA, C. A.—Du climat de Madère. 8°. (1859.)

MUSCHENBROEK, P. van.—Physicæ experimentales. 4°. (1729.)

NAISMITH, J.—General view of the agriculture of the county of Clydesdale. 8°. (1798.)

NETHERCOTE, H. O.—Meteorological register kept at Moulton Grange, Northhampton, 1857-84. (MS.)

NEUMAYER, G.—Grundzüge der climatischen Verhältnisse der Colonie Victoria. 4°. (1861.)

OFFICIAL YEAR BOOK OF THE SCIENTIFIC AND LEARNED SOCIETIES of Great Britain and Ireland. 8°. (1892.)

OLIVER, F. W.—Report on observations made in the Royal Gardens, Kew, upon Mr. Nowack's Weather Plant. 8°. (1890.)

PAGE, D.—Advanced text book of Physical Geography. 8°. (1864.)

PAYNE, J.—Geographical extracts, forming a general view of earth and nature. 8°. (1796.)

PEIRCE, C.—A meteorological account of the weather in Philadelphia, from Jan. 1, 1790, to Jan. 1. 1847. 12°. (1847.)

PHILADELPHIA, AMERICAN PHILOSOPHICAL SOCIETY.—Proceedings Vol. VIII. and parts 67 and 68, 1861-2. 8°. (1862.)

POORE, G. V.—London (ancient and modern) from the sanitary and medical point of view. 8°. (1889.)

PROCLI de Sphaera Liber. 8°. (1547.)

RICHARD, L'ABBÉ.—Histoire naturelle de l'air et des météores. 10 vols. 12°. (1770-1.)

ROBINSON, T.—New observations on the natural history of this world of matter and this world of life. 8°. (1696.)

[ROLLESTON G.]—Report on Smyrna. 8°. (1856.)

ROOKE, H.—A meteorological register kept at Mansfield Woodhouse, in Nottinghamshire, from 1785 to 1795, and 1797 to 1805. 8°. (1795-1806.)

RUSSELL, P.—A treatise of the plague at Aleppo 1760 to 1762. 4°. (1791.)

SCOTT, R. H.—Notes on the climate of the British Isles. 8°. (1892.)

SEARLE, J.—An ephemeris for nine years, 1609 to 1617. 8°. (1609.)

SHORT, T.—A comparative history of the increase and decrease of mankind in England, &c., also a meteorological discourse. 4°. (1767.)

————New observations, natural, moral, civil, political, and medical, on city, town, and country, bills of mortality. 8°. (1750.)

SMITH, C. I.—Statistical Report on the Mysore. 8°. (1854.)

SOUTH KENSINGTON MUSEUM.—Handbook to the special Loan Collection of Scientific Apparatus. 8°. (1876.)

SPARKS, E. I.—The Riviera. 8°. (1879.)

THE COMPLETE BOOK OF KNOWLEDGE. 12°.

THE HOROSCOPE. A miscellany of astrology, astronomy, phrenology, meteorology, &c. Vol. I., Nos. 1 to 6. 8°. (1841.)

THE PRESENT STATE OF PERU. 4°. (1805.)

THE SHEPHERD'S KALENDAR. 12th ed. 12°.

TROTTER, J.—General view of the agriculture of the County of West Lothian. 4°. (1794.)

UNGER, F., UND TH. KOTSCHY.—Die Insel Cypern, ihrer physischen und organischen Natur nach, mit Rücksicht auf ihre frühere Geschichte. 8°. (1865.)

VENERIO, G.—Osservazioni meteorologiche fatte in Udine nel friuli pel quarantennio 1803-1842. F°. (1851.)

VICTORIA.—The statistical register of Victoria, from the foundation of the colony. 8°. (1854.)

WARD, T. O.—On the medical topography of Shrewsbury and its neighbourhood. 8°. (1841.)

WARK, REV.— —Method of determining the strength and direction of earthquakes. 8°. (1771.)

WELLS, W. C.—On Dew and several appearances connected with it. 8°. (1877.)

WHITE, G.—The natural history of Selborne. 12°.

WILKES, C.—Theory of the Winds. 8°. (1856.)

WILLIAMS, C. T.—The influence of Climate in the prevention and treatment of pulmonary consumption. 8°. (1877.)

WILLIAMS, J.—The topography and climate of Aspley Guise. 2nd ed. 8°. (1858.)

WITTMAN, W.—Travels in Turkey, Asia Minor, Syria, and across the desert into Egypt, during the years 1799 to 1801. 4°. (1803.)

W———— J.—Systema Agriculturæ. 2nd ed. F°. (1675.)

[W.———— I. P.].—Snow-flakes, a chapter from the book of nature. 8°. (1863.)

APPENDIX VI.

DONATIONS RECEIVED DURING THE YEAR 1892.

Presented by Societies, Institutions, &c.

ADELAIDE, GOVERNMENT OBSERVATORY.—Meteorological Observations, 1889.—Rainfall in South Australia, Oct. 1891 to July 1892.

ALLAHABAD, METEOROLOGICAL OFFICE.—Annual statement of Rainfall in the North-Western Provinces and Oudh, 1891.

BARBADOES, COLONIAL SECRETARY'S OFFICE.—Returns of Rainfall, April 11 to Dec. 11 (incomplete).

BATAVIA, MAGNETICAL AND METEOROLOGICAL OBSERVATORY.—Observations, 1890.—Rainfall in the East Indian Archipelago, 1890.

BERLIN, DEUTSCHE METEOROLOGISCHE GESELLSCHAFT.—Meteorologische Zeitschrift, Jan. to Nov.

BERLIN, GESELLSCHAFT FÜR ERDKUNDE.—Verhandlungen, Band XVIII. No. 9 to Band XIX. No. 8.—Zeitschrift, Band XXVI. No. 6 to Band XXVII. No. 8.

BERLIN, KÖN. PREUSS. METEOROLOGISCHES INSTITUT.—Abhandlungen, Band I. Nos. 4 and 5.—Ergebnisse der meteorologischen Beobachtungen, 1889, Heft 3; 1891, Heft 2; and 1892, Heft 1.

BOMBAY, GOVERNMENT OBSERVATORY.—Magnetical and Meteorological Observations, 1890.

BOSTON, NEW ENGLAND WEATHER SERVICE.—Bulletin Dec. 1891, Jan. and March to Nov. 1892.

BRISBANE, CHIEF WEATHER BUREAU.—Daily Weather Charts of Australia, June to Dec. 1890, and April 1891.

BRISBANE, GENERAL REGISTER OFFICE.—Annual Report of the Registrar General for Queensland.—Report on the vital statistics, Oct. 1891 to Oct. 1892.

BRUSSELS, INSTITUT NATIONAL DE GÉOGRAPHIE.—Bulletin Météorologique, Dec. 1891 to Nov. 1892.

BRUSSELS, OBSERVATOIRE ROYAL DE BELGIQUE.—Annales. Observations météorologiques d'Uccle, Jan. to May.—Annuaire, 1892.

BUDAPEST, K. UNG. CENTRAL-ANSTALT FÜR METEOROLOGIE UND ERDMAGNETISMUS.—Jahrbuch, 1889.

BUKHAREST, INSTITUT MÉTÉOROLOGIQUE DE ROUMANIE.—Annales, Tome V. 1889.—Buletinul Observatiunilor Meteorologice din Roumania, Jan. to Nov. (August missing).

CAIRO SOCIÉTÉ KHÉDIVIALE DE GÉOGRAPHIE.—Bulletin, IIIe Série, Nos. 7, 8, and 10.

CALCUTTA, METEOROLOGICAL OFFICE.—India Daily Weather Report, Dec. 7, 1891, to Dec. 2, 1892.—Indian Meteorological Memoirs, Vol. V. part 1.—Memorandum on the Snowfall in the mountain districts bordering Northern India and the abnormal features of the weather in India during the past five months [Jan. to May], with a forecast of the probable character of the South-west Monsoon rains of 1892.—Monthly Weather Review, May 1892 to May 1892.—Registers of original observations, reduced and corrected, May 1891 to May 1892 (Dec. missing).—Report on the Meteorology of India in 1890.

CAMBRIDGE, MASS., NEW ENGLAND METEOROLOGICAL SOCIETY.—Investigations, 1890.—The Lawrence Tornado of July 26, 1890. By W. M. Davis, H. H. Clayton, and H. F. Mills.

CAPE TOWN, METEOROLOGICAL COMMISSION.—Report 1891.

CAPE TOWN, SOUTH AFRICAN PHILOSOPHICAL SOCIETY.—Transactions, Vol. VI. 1889-92.

CHEMNITZ, KÖNIGL. SÄCHSISCHES METEOROLOGISCHES INSTITUT.—Jahrbuch, 1891, part 1.

CHRISTIANIA, EDITING COMMITTEE, NORWEGIAN NORTH-ATLANTIC EXPEDITION, 1876-1878.—Zoology, Crinoida, and Echinida, by D. C. Danielssen.

CHRISTIANIA, NORSKE METEOROLOGISKE INSTITUT.—Jahrbuch, 1890.

COLOMBO, SURVEYOR GENERAL'S OFFICE.—Meteorology of Ceylon in 1891.

COPENHAGEN, DANSKE METEOROLOGISKE INSTITUT.—Annuaire Météorologique, 1888, pt. 2; 1889; 1890, pts. 1 and 3; 1891, pts. 1 and 3.—Bulletin Météorologique du Nord, Dec. 1891 to Nov. 1892.

CRACOW, K. K. STERNWARTE.—Meteorologische Beobachtungen, Sept. 1891 to May 1892.

CROYDON, MICROSCOPICAL AND NATURAL HISTORY CLUB.—Daily Rainfall in the Croydon district, Dec. 1891 to Nov. 1892.—Report of the Meteorological Sub-Committee for 1891.

DORPAT, K., LIVLÄNDISCHE GEMEINNÜTZIGE UND ÖKONOMISCHE SOZIETAT.—Bericht über die Ergebnisse der Beobachtungen an den Regenstationen für die Jahre 1889-91.

DORPAT, OBSERVATORIUM.—Meteorologische Beobachtungen, 1890 and 1891.

DUBLIN, GENERAL REGISTER OFFICE.—Annual Report of the Registrar General (Ireland), 1890.—Weekly Returns of Births and Deaths, 1892.

DUBLIN, ROYAL DUBLIN SOCIETY.—Scientific Proceedings, Vol. VII. (N.S.), parts 3 and 4.—Scientific Transactions, Vol. IV. (Series 2), parts 9 to 13.

DUBLIN, ROYAL IRISH ACADEMY.—Proceedings, Third Series, Vol. II. No 2.—Transactions, Vol. XXIX. parts 17 to 19.

EDINBURGH, FISHERY BOARD FOR SCOTLAND.—Annual Report, 1891, part 3.

EDINBURGH, GENERAL REGISTER OFFICE.—Quarterly Returns of the Births, Marriages and Deaths registered in Scotland for the four quarters ending Sept. 30, 1892.

EDINBURGH, ROYAL SCOTTISH GEOGRAPHICAL SOCIETY.—Scottish Geographical Magazine, 1892.

EDINBURGH, ROYAL SOCIETY.—Proceedings. Vol. XVIII. 1890-1.

EDINBURGH, SCOTTISH METEOROLOGICAL SOCIETY.—Journal. Third Series, No. VIII.

FIUME, I. R. ACCADEMIA DI MARINA.—Meteorological Observations, Aug. 1891 to May 1892.

GENEVA, SOCIÉTÉ DE GÉOGRAPHIE.—Le Globe, Tome XXXI.

GLASGOW, PHILOSOPHICAL SOCIETY.—Index to the Proceedings, Vol, I. to XX. 1811-89.—Proceedings, Vols. XXII. and XXIII. 1890-92.

GREENWICH, ROYAL OBSERVATORY.—Magnetical and Meteorological Observations, 1889.—Report of the Astronomer Royal to the Board of Visitors, June 4, 1892.

HALLE, K. LEOPOLD-CAROLINISCHE DEUTSCHE AKADEMIE DER NATURFORSCHER.—Leopoldina, Heft XXVII. 1891.

HAMBURG, DEUTSCHE SEEWARTE.—Aus dem Archiv, 1891.—Deutsche ueberseeische meteorologische Beobachtungen, Heft IV.—Ergebnisse der meteorologischen Beobachtungen im Systeme der Deutschen Seewarte für das Lustrum 1886-1890.—Ergebnisse der meteorologischen Beobachtungen in Deutschland, 1890.—Monatsbericht, May to Dec. 1891.—Wetterbericht, 1891.

HOBART, OBSERVATORY.—Monthly record of results of meteorological observations at Hobart and various localities in Tasmania, Oct. to Dec. 1891.

HONG KONG, OBSERVATORY.—Observations, 1891.

KARLSRUHE, CENTRALBUREAU FÜR METEOROLOGIE UND HYDROGRAPHIE IM GROSSHERZOGTHUM BADEN.—Die Ergebnisse der meteorologischen Beobachtungen, 1891.—Niederschlagsbeobachtungen der meteorologischen Stationen im Grossherzogthum Baden, 1890-1.

KEW, OBSERVATORY.—Report of the Kew Committee for the fourteen months ending Dec. 31, 1891.

KINGSTON, INSTITUTE OF JAMAICA.—The Rainfall of Jamaica. By Maxwell Hall.

LEON, ESCUELA DE INSTRUCCION SECUNDARIA.—Regimen pluvometro y algo sobre climatologia de Leon. Por M. Leal.—Resumen general de las observaciones meteorologicas, 1891.

LISBON, OBSERVATORIO DO INFANTE D. LUIZ.—Annaes, Vol. XXVI. 1888.—Observacoes dos Postos Meteorologicas, 1886.

LISBON, SOCIEDADE DE GEOGRAPHIA.—Boletim, 10a Serie, No. 1 to 11a Serie, No. 2.

LONDON, BRITISH ASSOCIATION.—Report, 1891.

LONDON, COLONIAL OFFICE.—Annual Meteorological Report, Straits Settlements, 1891.—Annual Report of the Mauritius Observatory, 1890.—Report on the Medical Department of the State of Sungei Ujong, 1891. By W. L. Braddon, Residency Surgeon.

LONDON, GENERAL REGISTER OFFICE.—Annual Summary of Births, Deaths, and Causes of Death in London and other great towns, 1891.—Quarterly Returns of

Marriages, Births and Deaths, for the four quarters ending Sept. 30, 1891.—Weekly Returns of Births and Deaths, 1892.

London, Geological Society.—Quarterly Journal, Vol. XLVIII. 1892.

London, Imperial Institute.—Report of Progress from the date of its establishment to the 26 Nov. 1892.—Year Book, 1892.

London, Institution of Electrical Engineers.—Index to the Journal, Vols. XI-XX. 1882-91.—Journal, Nos. 95 to 100.

London, Meteorological Office. — Daily Weather Reports, 1892. — Weekly Weather Reports, 1892.—Hourly means of the readings from the self-recording instruments at the four Observatories under the Meteorological Council, 1888.—Report of the Meteorological Council to the Royal Society, for the year ending March 31, 1891.—Ten years' Sunshine in the British Isles, 1881-90.—Harmonic analysis of hourly observations of air temperature and pressure at British Observatories.—Annual Report of the Council of the Yorkshire Philosophical Society, 1891.—Atmospheric radiation of heat and its importance in Meteorology. By Cleveland Abbe.—On the heat of Sunshine at London during the years 1855-74, as registered by Campbell's method. By H. E. Roscoe and B. Stewart.—Plate 23. (Terrestrial Magnetism) from Keith Johnston's Physical Atlas.—Radiation of atmospheric air. By C. C. Hutchings.—Report of the Queensland Government Meteorological Observer, 1881.—U. S. International Daily Charts, July 1 to Dec. 31, 1884.—Bulletin quotidien de l'Algérie, Oct. 1891 to May, and Aug. to Oct. 1892.—Bulletins météorologiques publiés par la 6me section de la Société d'Encouragement de l'Industrie et du Commerce à Varsovie, 1890.—Ergebnisse der ombrometrischen Beobachtungen in Böhmen, 1889.—Ergebnisse der Wasserstandsbeobachtungen an dem Flüssen Böhmens, 1889.—Ueber mehrjährige Perioden der Witterung, von Dr. W. Köppen.

London, Physical Society.—Proceedings, Nos. 44 to 46.

London, Royal Agricultural Society.—Journal, Vol. II. part 4 to Vol. III. part 3.

London, Royal Astronomical Society.—Memoirs, Vol. L. 1890-1.—Monthly Notices, Vol. LII. No. 2 to Vol. LIII. No. 1.

London, Royal Botanic Society.—Quarterly Record, Nos. 48 to 51.

London, Royal Institution of Great Britain.—Proceedings, No. 85.

London, Royal Society.—Catalogue of Scientific Papers (1874-83). Vol. IX.—Proceedings, Nos. 303 to 316.—Einige Resultate aus dem meteorologischen Beobachtungen, angestellt auf der Sternwarte zu Lund in den Jahren 1741-1870. Von. A. V. Tidblom.—Nederbördsmängden i Sverige härledd ur de vid statens meteorologiska Stationer under Åren 1860-1872 anställda iakttagelser af R. Rubenson.

London, Sanitary Institute.—Transactions, Vol. XII. 1891.

London, Society of Arts.—Journal, 1892.

Lyons, Observatoire.—Météorologie Lyonnaise 1887-90. Par. C. Andre.

Madras, Government Observatory.—Results of the Meteorological Observations, 1861-90.

Madrid, Observatorio. —Resumen de las observaciones meteorológicas de Provincias, 1889.

Madrid, Sociedad Geographica.—Boletin, Tomo No. 4 XXXI. to Tomo XXXIII. No. 3.

Manchester, Literary and Philosophical Society.—Memoirs and Proceedings, Fourth Series, Vol. V.

Manila, Observatorio Meteorologico.—Observaciones verificadas, March to Sept. 1891.

Marlborough, College Natural History Society.—Report, 1891.

Mauritius, Royal Alfred Observatory.—Annual Report, 1890.—Meteorological Results, 1890-1.

Mazatlan, Observatorio Astronómico-Meteorologico.—Resumen de las observaciones meteorologicas, 1891.

Melbourne, Government Observatory.—Monthly Record of Results of observations in Meteorology, Terrestrial Magnetism, &c., July 1891 to June 1892.

Mexico Observatorio Astronómico Nacional de Tacubaya.—Anuario, 1893.

Mexico, Observatorio Meteorologico Magnetico Central.—Boletin Mensual, March and April, 1890.

Mexico, Sociedad Cientifica "Antonio Alzate."—Memorias, Tomo V. No. 1 to Tomo VI. No. 2.

Michigan, State Board of Health.—Principal Meteorological Conditions in Michigan, 1889.

Milan, R. Osservatorio di Brera.—Osservazione Meteorologische, 1891.

Montevideo, Observatorio Meteorológico del Colegio Pio de Villa Colon.—Boletin Mensual, June 1891.

Moscow, Société Impériale des Naturalistes.—Bulletin, 1891, No. 2, to 1892, No. 2.

Munich, K. B. Meteorologische Central-Station.—Beobachtungen der meteoro-

logischen Stationen in Kön. Bayern, Jahrgang XIII. Heft 3 to Jahrgang XIV. Heft 2.—Bericht über die Verhandlungen der internationalen Conferenz der Repräsentanten der Meteorologischen Dienste aller Länder zu München 26 August bis 2 September 1891.—Uebersicht über die Witterungsverhältnisse im Kön. Bayern, Nov. 1891 to Oct. 1892.

NATAL, OBSERVATORY.—Report of the Superintendent, 1890-1.

NEW YORK, ACADEMY OF SCIENCES.—Transactions, Vol. X. No. 7 to Vol. XI. No 5.

NEW YORK, CENTRAL PARK OBSERVATORY.—Abstracts of registers from self-recording instruments Nov. 1891 to Oct. 1892.

OTTAWA, GEOLOGICAL SURVEY DEPARTMENT.—Annual Report, Vol. IV. 1888-9.

OXFORD, RADCLIFFE OBSERVATORY.—Results of Meteorological Observations, 1887.

PARIS, BUREAU CENTRAL MÉTÉOROLOGIQUE.—Bulletin International, 1892.

PARIS, OBSERVATOIRE DE LA TOUR SAINT-JACQUES.—L'Atmosphère, Feb.-Nov.

PARIS, OBSERVATOIRE MUNICIPAL DE MONTSOURIS.—Annuaire, 1892-3.

PARIS, SOCIÉTÉ MÉTÉOROLOGIQUE DE FRANCE.—Annuaire, Oct. 1891 to June 1892.

PERPIGNAN, OBSERVATOIRE.—Bulletin Météorologique Annuel du Département des Pyrénées-Orientales, 1890. Par le Dr. Fines. —Observations Magnetiques 1890. Par M. P. Cœurdevache.

PHILADELPHIA, AMERICAN PHILOSOPHICAL SOCIETY.—Proceedings, Nos. 136 to 138.—Transactions, Vol. XVII. pts. 1 and 2.

POLA, K. k. HYDROGRAPHISCHES AMT.—Meteorologische und magnetische Beobachtungen, Nov. 1891 to Oct. 1892.

PORT-AU-PRINCE, OBSERVATOIRE MÉTÉOROLOGIQUE.—Meteorologische Beobachtungen, 1890.

PRAGUE, K. K. STERNWARTE.—Magnetische und Meteorologische Beobachtungen, 1891.

PRAGUE, OBSERVATOIRE D'ASTRONOMIE PHYSIQUE.—Le système du Monde Electrodynamique. Par. C. V. Zenger.

PUEBLA, OBSERVATORIO METEOROLOGICO DEL COLEGIO DEL ESTADO.—Resumen correspondiente a cada dia, Sept. 1891 to June 1892.

RIO DE JANEIRO, OBSERVATOIRE.—Le Climat de Rio de Janeiro, par L. Cruls.—Revista do Observatorio, Nov. 1891 and Jan. 1892.

ROCHESTER, U.S., ACADEMY OF SCIENCES.—Proceedings, Vol. I. pt. 2.

ROME, SPECOLA VATICANA.—Pubblicazioni, Fasc. II.

ROME, UFFICIO CENTRALE METEOROLOGICO E GEODINAMICO ITALIANO.—Annali, Serie seconda Vol. IX. 1887, Vol. X. 1888, and Vol. XI. pt. 3, 1889.

SAN FERNANDO, INSTITUTO Y OBSERVATORIO DE MARINA.—Anales Seccion 2a, Observaciones Meteorológicas y Magnéticas, 1891.

SAN SALVADOR, INSTITUTO NACIONAL.—Observaciones meteorológicas, Sept. to Dec. 1891, and Feb. 1892.

SAN SALVADOR, OBSERVATORIO ASTRONÓMICO Y METEOROLÓGICO.—Resúmen Anual de las Observaciones Meteorológicas, 1891.

STOCKHOLM, METEOROLOGISKA CENTRAL-ANSTALTEN.—Månadsöfversigt of Väderleken i Sverige, Jan. to Oct.

STONYHURST, COLLEGE OBSERVATORY.—Results of Meteorological and Magnetical Observations, 1891.

ST. PETERSBURG, KAISERLICHE AKADEMIE DER WISSENSCHAFTEN.—Communications from the International Polar Commission. Seventh (last) part.—Repertorium für Meteorologie. Band XIV.

ST. PETERSBURG, PHYSIKALISCHES CENTRAL OBSERVATORIUM.—Annalen, 1890, pt. 2.

STRASSBURG, METEOROLOGISCHE CENTRAL-STATION.—Ergebnisse der meteorologischen Beobachtungen im Reichsland Elsass-Löthringen, 1890.

STUTTGART, METEOROLOGISCHE CENTRALSTATION.—Meteorologische Beobachtungen in Württemberg, 1891.

SYDNEY, GOVERNMENT OBSERVATORY.—Daily Weather Charts of Australia and New Zealand, July to Sept 1891.—Map of Isothermal Lines showing mean shade Temperature for New South Wales.—Meteorological Observations, July 1891 to June 1892.—Results of Meteorological Observations made in New South Wales, 1880-4 and 1889.—Results of Rain, River, and Evaporation Observations made in New South Wales, 1890.

SYDNEY, ROYAL SOCIETY OF NEW SOUTH WALES.—Journal and Proceedings, Vol. XXV. 1891.

TAIPING, GOVERNMENT SECRETARY'S OFFICE.—Annual Report on the State of Perak for the year 1891. By W. H. Treacher, C.M.G., Acting British Resident, Perak.

TIFLIS, PHYSIKALISCHES OBSERVATORIUM.—Beobachtungen der Temperature des Erdbodens, 1884-5. Nebst Anhang: Beobachtungen am Radiations Thermometer in den Jahren 1881-4.—Magnetische Beobachtungen, 1890.—Meteorologische Beobachtungen, 1890.

TOKIO, METEOROLOGICAL CENTRAL OBSERVATORY.—Monthly summaries and monthly means, 1890.

Tonga, Premier's Office.—Statistics of the Tonga Islands, 1891.

Toronto, Meteorological Office.—Monthly Weather Review, Sept. 1891 to Aug. 1892.—Report of the Meteorological Service of the Dominion of Canada, 1888.—Toronto General Meteorological Register, 1891.

Trieste, Osservatorio Marittimo.—Rapporto Annuale, 1889.

Turin, Osservatorio della R. Università.—Di un Notevole Tipo Isobarico Subalpino. Nota del Dr. G. B. Rizzo.—Osservazioni Meteorologische, 1890.

Turin, Società Meteorologica Italiana.—Annuario Meteorologico Italiano, 1892.—Bollettino Mensuale publicato per cura dell' Osservatorio Centrale del Real Collegio Carlo Alberto, Dec. 1891 to Nov. 1892.

Upsala, Observatoire Météorologique de l'Université.—Bulletin Mensuel, 1891.

Utrecht, K. Nederlandsch Meteorologische Institut.—Nederlandsch Meteorologische Jaarboek, 1888, pt. 2, and 1891.

Vienna, K. K. Ackerbau-Ministerium.—Resultate forstlich-meteorologischer Beobachtungen, 1885-7, pt. 2. Von Dr. J. R. von Lorenz-Liburnau.

Vienna, K. K. Centralanstalt fur Meteorologie und Erdmagnetismus.—Beobachtungen, July 1891 to April 1892.—Jahrbuch, 1890.

Vienna, Oesterreichische Gesellschaft für Meteorologie.—Meteorologische Zeitschrift, Jan.-Nov.

Washington, Department of Agriculture.—Meteorological work for Agricultural Institutions. By M. W. Harrington.—Report of the Chief of the Weather Bureau 1891. By M. W. Harrington.

Washington, Geological Survey.—Tenth Annual Report, 1888-9.

Washington, Hydrographic Office.—Pilot Charts of the North Atlantic Ocean, 1892.

Washington, Naval Observatory.—Magnetic Disturbances, 1892.—Magnetic Observations, 1890-1.—Meteorological Observations and Results, 1883-8.—Report of the Superintendent for the year ending June 30, 1891.—Report upon some of the Magnetic Observatories of Europe.

Washington, Smithsonian Institution.—Report, 1890.

Washington, Weather Bureau.—A Report on the relations of Soil to Climate. By E. W. Hilgard.—Charts showing average Velocity and Direction of the Winds, prepared from observations for seventeen years.—Charts showing Maximum and Minimum temperatures, by decades, for all years.—Diurnal fluctuation of Atmospheric Pressure at twenty-nine selected stations in the United States. By Brig.-Gen. A. W. Greely.—Fluctuations of Ground-Water at Whitewater, Wisconsin. By F. H. King.—Index of Meteorological Observations in the United States from the earliest records to January 1890.—International Monthly Charts of mean Pressures and Wind Directions at 7 a.m., for 1882 and 1883.—Irrigation and Water Storage in the Arid Regions.—Monthly Weather Review, Sept. 1891 to Sept. 1892.—Notes on a new method for the discussion of Magnetic Observations. By F. H. Bigelow.—Notes on the climate and meteorology of Death Valley, California. By M. W. Harrington.—Report of Assistant Professor C. T. Marvin, in charge of the Instrument Division.—Some physical properties of Soils in their relation to Moisture and Crop distribution. By M. Witney.—Wreck Chart of the Great Lakes, 1886 to 1891.

Watford, Hertfordshire Natural History Society.—Transactions, Vol. VI. pt. 4 to Vol. VII. pt. 2.

Wellington, Registrar General's Office.—Statistics of the Colony of New Zealand, 1890.

Wellington College, Natural Science Society.—Annual Report, 1891.

Zi-ka-Wei, Observatoire Magnétique et Météorologique.—Bulletin Mensuel, 1890.

Zurich, Schweizerische Meteorologische Central-Anstalt.—Annalen, 1889.

Presented by Individuals.

Abbadie. A. d'.—Observations relatives à la Physique du Globe faites au Brézil et en Ethiopie.

Abercromby, Hon. J.—" The Times " Register of Events in 1879.

André, C.—Relations des phénomènes météorologiques déduits de leurs variations diurnes et annuelles.

Assmann, Dr. R.—Das Aspirationspsychrometer.

Auchincloss, W. S.—Yearly Tides.

Author, The.—Problems in physics and their application to dynamic meteorology. By Ganymede.

Baturoni, G.—Diagrama de Presion, Temperatura, Lluvia, y Viento, de Veracruz, Nov. 1891 to Oct. 1892 (MS.).—Registro de observaciones de Veracruz, Nov. 1891 to Oct. 1892 (MS.).

BAXENDELL, J.—Abstract of meteorological results for the borough of Southport; Averages for the 2) years 1872-91.—Abstract of results of meteorological observations at Southport for 1891.—Meteorological observations at Southport, Dec. 19, 1891, to Dec. 16, 1892.

BENN, T. G.—The weather of 1891 at Newton Reigny, Penrith.

BINNIE, A. R.—On average annual rainfall.

BLANFORD, H. F.—On meteorological observations in tropical countries.

BROWN, A. AND BOOBBYER, P.—The Meteorology of Nottingham, 1891.

CHWOLSON, O.—Ueber den gegenwärtigen Zustand der Actinometrie.

CLARK, J. E.—The Natural History Journal and School Reporter, 1892.

CLEMENTS, H.—Clements' Weather Almanack, 1893.—Clements' Weather Chart Almanack for 1893.—Weather Prediction.

COOKE, R.—Rainfall at Detling, near Maidstone, 1891 (MS.).

COVENTRY, F.—Monthly rainfall 1880-91 at Ketton Hall, Stamford (MS.).

COXEN, MRS.—Meteorological observations at Bulimba, Queensland, July 1891 to June 1892 (MS.).

CURTIS, H. P. Some Great Storms. By W. A. Eddy.

DALLAS, W. L.—Cyclone Memoirs. Part IV. Arabian Sea.—Memoir on the Winds and Monsoons of the Arabian Sea and North Indian Ocean.—On the Meteorology and Climatology of Northern Afghanistan.—The meteorological features of the southern part of the Bay of Bengal.

DAVIS, W. M.—The eye of the storm. By S. M. Ballou.—The theories of artificial and natural rainfall.

DIXON, H. P.—Wiltshire Rainfall, Dec. 1891 to Nov. 1892.

DOYLE, P.—Indian Engineering, 1892.

DULIER, COL.—A natural process of dissolution for smoke and fogs.

EDITOR.—American Meteorological Journal, Dec. 1891 to Dec. 1892.

EDITOR.—Ciel et Terre, 1892.

EDITOR.—Discovery, Vol. II. Nos. 1 to 11.

EDITOR.—Electrical Review, 1892.

EDITOR.—Il Rosario e la Nuova Pompei. Anno VIII. No. 11 to Anno IX. No. 10.

EDITOR.—Nature, 1892.

EDITORS.—The Observatory, 1892.

ELLIOTT, Dr. G.—Meteorological observations taken at Caterham, 1892 (MS.).

ELLIS, W.—Map showing lines of equal magnetic declination for January 1, 1892.

ESPIN, REV. T. E.—Twenty years' observations of Thunderstorms.

ETIENNE, DR. E.—Le climat de Banana (Congo) en 1890 suivi des observations météorologiques faites du Dec. 1, 1889, au Mai 16, 1891.

FARR, C. C.—A determination of the magnetic elements at the Physical Laboratory, University of Sydney.

FINES, DR.—L'Hiver de 1890 à 1891 à Perpignan et ses effets.

FOX, W. L.—Meteorological Tables for Falmouth and the Scilly Islands, 1891.

FRY, CAPT. A.—Meteorology and its uses at sea.

FUESS, R.—Meteorologische Instrumente und physikalische Hülfs-Apparate.

GARRIGOU, DR. F.—Leçon d'ouverture du cours d'hydrologie.

GLEDHILL, G. W.—Meteorological observations taken at High Harrogate, 1892 (MS.).

GLYDE, E. E.—Abstract of meteorological observations made at Babbacombe, Torquay, 1891.—Meteorological Summaries for Jan. to Nov., made at Babbacombe, Torquay.—Ninth Report of the Committee on the climate of Devon, 1890.

GREENWOOD, CAPT. W. N.—Greenwood's Kludonometric Tide Tables, 1893.

GRISSINGER, DR. K.—Untersuchungen über die Tiefen-und Temperatur-Verhältnisse des Weissensees in Kärnten.

HALL, M.—Jamaica Rainfall, 1870-89, and 1890-91.—Jamaica Weather Report, Nov. 1891 to Oct. 1892.

HAMBERG, H. E.—Sur une prétendue période de presque 26 jours dans les orages.

HAMLYN, J.—Meteorological observations taken at Buckfastleigh, Devon, 1892 (MS.).

HANN, DR. J.—Einige Resultate stündlicher meteorologischer Beobachtungen auf dem Gipfel des Fuji in Japan.—Weitere Untersuchungen über die tägliche Oscillation des Barometers.

HARRIES, H.—Cold.—Ein Willkommen der Sechsten allgemeinen Versammlung der deutschen meteorologischen Gesellschaft.

HARVEY, REV. C. W.—Summary of meteorological observations of Temperature and Rainfall taken at Throcking Rectory, Buntingford, Herts, 1880-9.

HELLMANN, DR. G.—Die erste Ballonfahrt zu wissenschaftlichen Zwecken.

HOOKER, R. H.—War and the weather. By E. Powers, C.E.

HOPKINSON, J.—Climatological observations in Hertfordshire, 1890.—Hertfordshire Rainfall, Percolation, and Evaporation.—Meteorological observations taken at the Grange, St. Albans, 1890.—Report on the Rainfall in Hertfordshire, 1890.

HUNTER, J.—Meteorological observations at Belper, 1892.

IHNE, DR. E.—Phänologische Beobachtungen, 1891.

KAMMERMANN, A.—Résumé météorologique de l'année 1891 pour Genève et le Grand Saint-Bernard.

KLOSSOVSKY, A.—Revue Météorologique. Travaux du réseau météorologique du sud-ouest de la Russie, l'année 1891.

LANCASTER, A.—Le climat de la Belgique en 1891.

LISTER, M.—Annual Report on the State of Negri Sembilan, 1891.

LOVEL, J.—The Cloudburst at Langtoft, Yorkshire.—Waterspouts on the Yorkshire Wolds.—Cataclysm at Langtoft and Driffield. By J. D. Hood.

MANSON, M.—The circulation of the atmosphere of planets.

MARCHI, L. DE.—I Cicloni Atlantici e le resenti intemperie.—Sulla teoria dei cicloni.

MARKHAM, C. A.—Meteorological Report for Northamptonshire, Oct. 1891 to Sept. 1892.

MARTEN, H. J. (THE LATE).—The great earthquake in Japan, 1891. By J. Milne, F.R.S., and W. K. Burton.

MAWLEY, E.—Meteorological observations made at Berkhamsted, Nov. 19, 1891, to Dec. 20, 1892.—The percolation of rain through comparatively light and through comparatively heavy soil.—The Rosarian's Year Book, 1892.

MAXWELL, W. E.—Annual Report of the State of Selangor, 1891.

McLANDSBOROUGH, J., AND PRESTON, A. E.—Meteorology of Bradford for 1891.

MELDRUM, C.—The Hurricane in Mauritius, April 29, 1892.

MELLISH, H.—Summary of observations at Hodsock Priory, Worksop, 1891 (MS.).

MIDGLEY, W. W.—Summary of meteorological observations at Bolton, 1891.

MILL, DR. H. R.—Fourth and final report of the British Association Committee appointed to arrange an investigation of the seasonal variations of temperature in lakes, rivers, and estuaries in various parts of the United Kingdom.

MOORE, DR. J. W.—Abstract of meteorological observations taken at Dublin, 1891.

NOWACK, J. F.—New system of meteorological and telluric forecasts for land and sea.

PAGE, MRS.—Meteorological Register kept by the late Rev. A. J. T. Morris at Muthill, Perthshire, 1865-71, and at Crieff, 1872-4 (MS.).

PAGET, J.—Weekly charts from a self-recording Richard Barograph at Stuffynwood Hall, Mansfield, 1891 (MS.).

PARNABY, J. M.—Meteorological Report, Albert Park, Middlesborough, Dec. 1891 to Nov. 1892 (MS.).

PEARSON, C. N.—Meteorological observations taken at Reading, 1892 (MS.).

PEEK, C. E.—Meteorological observations at Rousdon Observatory, Devonshire, 1890-1, and results for 1886 to 1890.

PHILLIPS, F. H.—Meteorological observations taken at Brighton, 1892 (MS.).

POWERS, E.—A criticism of Prof. Newcombe's contribution to the article in the North American Review for Oct. 1891, entitled "Can we make rain?"

PRINCE, C. L.—The summary of a meteorological journal at Crowborough Hill, Sussex, 1891.

PRINCE, J. E.—Phenology and Rural Biology.

RAJNA, M.—Sull' escursione diurna della declinazione magnetica a Milano in relazione col periodo delle macchie solari.

REID, C.—The climate of Europe during the Glacial Epoch.

RIGGENBACH, A.—Die Geschichte der meteorologischen Beobachtungen in Basel.

RODGER, J. P.—Annual Report of the State of Pahang, 1891.

ROTCH, A. L.—Artificial Rain; a review of the subject to the close of 1889. By R. de C. Ward.—Mountain meteorology.—New high-level meteorological observatories in France. Proceedings at Meeting of New England Meteorological Society, April 23, 1892.—The anemograph for vertical currents at the Blue Hill Observatory. By S. P. Fergusson.—The International Meteorological Conference at Munich.—The Mountain Meteorological stations of the United States.—The theories of artificial and natural rainfall. By W. M. Davis.

RUSSELL, H. C.—A cyclonic storm or tornado in the Gwydir district.—Anniversary Address delivered before the Royal Society of New South Wales, May 1892.—Notes on the rate of growth of some Australian trees.—Physical Geography and climate of New South Wales. Second Edition.

SALLE, O.—Das Wetter, 1892.

SAUSSURE, H. de.—Observations Météorologiques faites au Col du Géant du 5 au 18 Juillet 1788. Par H. B. de Saussure.

SCOTT, R. H.—Atlantic weather and its connection with British weather.

SHAPLEY, C.—Torquay Local Board, Annual Reports of the Medical Officer of Health, 1879 to 1891. (1882 wanting).

SHAW, REV. G. A.—Meteorological observations taken at Farafangana, Madagascar, Jan.-Sept. 1892.

SHEWARD, R.—Eastbourne: abstracts of weather reports for five years, 1887-92.

SLADE, F.—Meteorological observations at Beckford, Tewkesbury, 1891.

SOUTHALL, H.—The great frost of 1890-1.

SPARKS, F. J.—Meteorological observations taken at Crewkerne, 1892 (MS.).—Rainfall at Crewkerne, 1891 (MS.).

SPIEGELHALTER, E. K.—Meteorological observations taken at Malton, 1892 (MS.).—Report on the sanitary condition of the Malton Urban Sanitary District, 1891. By R. S. Marsden.

STOKES, J.—Borough of Margate. Annual Report of the Medical Officer of Health: also meteorological report, 1891.

SYMONS, G. J.—Symons's British Rainfall, 1891.—Symons's Monthly Meteorological Magazine, 1892.—Book containing newspaper cuttings and various meteorological memoranda collected by the Meteorological Society of Great Britain, 1837–1843.—Distribution of rainfall during the great storm of Oct. 3 and 4, 1869. By J. B. Francis.—Memoranda made during the appearance of the Aurora Borealis on Nov. 18, 1835. By C. C. Christie.

TARNER, G. E.—Detonation in Meteorology.

TAYLOR AND FRANCIS, MESSRS.—Taylor's Calendar of the Meetings of the Scientific Bodies of London, 1892–3.

TINSLEY, G. W.—Sun spots.

TOMLINSON, S.—Report of the deputy Executive Engineer in charge of Bombay Waterworks, 1891–2.

TROMELIN, G. le G. de.—Circulation de l'atmosphère surfaces isodenses.—Grains, etc.—Note sur les causes originelles des cyclones et leurs signes précurseurs.

TYRER, R.—Cheltenham in its Sanitary Aspects.—Rainfall in the County of Gloucester. Jan.–Nov.—The Meteorology of Cheltenham in 1891.

VINCENT, J.—Cirro-stratus et Alto-stratus.—Contrôle des abris thermométriques de l'observatoire d'Uccle.

WATSON, REV. J.—Meteorological observations taken at Guisborough, 1892 (MS.).

WATTS, F.—Meteorological register kept at the Government Laboratory, St. John's, Antigua, 1891 (MS.).—Returns of Rainfall in Antigua, 1890–1.

WHITEHEAD, T.—Barbados Rainfall, Feb. 1890 to Aug. 1891. (Incomplete.)

WILD, DR. H.—Instrument für erdmagnetische Messungen und astronomische Ortsbestimmungen auf Reisen.

WILMSHURST, A. J.—Temperature and Rainfall at Manor Park, Essex, Dec. 1891 to Nov. 1892 (MS.).

WILSON, J. H.—Harrogate Weather in 1891.

WOOD, B. T.—Weekly charts from a self-recording Richard Barograph at Conyngham Hall, Knaresboro', 1891 (MS.).

APPENDIX VII.

REPORTS OF OBSERVATORIES.

THE METEOROLOGICAL OFFICE.—Lieut.-Gen. R. Strachey, R.E., C.S.I., F.R.S., Chairman of Council; Robert H. Scott, M.A., F.R.S., Secretary; Nav.-Lieut. C. W. Baillie, F.R.A.S., Marine Superintendent.

MARINE METEOROLOGY.—*Current Charts for all Oceans.*—The work of extraction of information from the logs of the Royal Navy has been carried as far back as to the year 1830, at which period it has been decided to stop the research. As the resulting charts, compiled solely from British data, were not as well covered with data in the less frequented parts of the ocean, especially of the Pacific, as might be wished, application has been made to the French, the Dutch and the German authorities respectively for copies of the current observations, for these less frequented regions, which might be contained in their archives. By this means a considerable amount of valuable material has been acquired, about 9,000 observations in the first case, 3,500 in the second, and about 13,000 in the third. It must, however, be recollected that on charts of such magnitude, each covering an enormous area, and each for one month, one thousand observations make but little show. The form in which these charts will ultimately be published has not yet been considered. To reproduce them in fac-simile is of course impracticable, and much judicious generalisation must take place in order to give a fair representation of the copious mass of material available.

The Meteorology of the Red Sea.—These charts are now in the engraver's hands, and it is hoped they will appear in the course of 1893.

The Meteorology of the South Sea.—The work of extraction of material for these charts has now been completed, and the delicate task of preparing them for publication has to be undertaken. The subjects to be discussed are pressure, wind, temperature of air and sea, currents, and occasional phenomena, such as ice.

Future Marine Work of the Office.—As a considerable number of the staff have been set free for other occupation by the completion of the first stage of the work last described, it has been decided by the Council to take up the discussion of the South Atlantic and of the West Coast of South America, as far as the meridian of 90° W. This work will at once be commenced.

WEATHER TELEGRAPHY.—There has been no change in the operations of this department during the year, but much time has been spent on the preliminary discussion and selection of stations to be included in a proposed publication of Mean Rain Tables for the British Isles for the decade 1881-90, as a continuation of the former publication, which covered the period 1866-80 and appeared in 1883.

LAND METEOROLOGY OF THE BRITISH ISLES.—The volume of the *Monthly Mean Readings* for five day periods for 1889 has appeared, and that for 1890 is nearly ready. The volume of *Observations from Stations of the Second Order* for 1888 is out, and that for 1889 is in the press.

The anemometer devised by Mr. W. H. Dines in the course of his experiments as a Member of the Wind Force Committee of the Royal Meteorological Society has been ordered by the Council, and will very shortly be erected for trial on the roof of the Office.—*March* 1893.

ROYAL OBSERVATORY, GREENWICH.—W. H. M. Christie, M.A., F.R.S., Astronomer Royal; Departmental Superintendent, William Ellis, F.R.A.S.; Assistant, William C. Nash.

No addition of instruments or change of methods has been made during the year 1892. Meteorological reports have been sent daily as usual to the Meteorological Office and weekly to the Registrar General of Births and Deaths in London. In the latter report, commencing with the year 1893, the average mean daily temperature employed has been that recently found from the discussion of the thermometrical observations for the fifty years 1841-1890. This discussion is very far advanced, and great part of the work is nearly in a state for the printer. The tables, as prepared, will give the mean temperature of each day in each separate month throughout the fifty years, as well as the maximum value on each separate day, and the minimum value on each separate day; with also tables of mean daily temperature, mean daily maximum temperature and mean daily minimum temperature, each daily mean in these latter tables being the mean of the values on the same day throughout the fifty years. The mean daily temperature in the years 1841 to 1847 depends generally on twelve observations daily, in 1848 on six values daily, and from 1849 on twenty-four values from the photographic register. A table showing the value of mean daily temperature as depending on the simple mean of the maximum and minimum is also given, as well as monthly means of all elements. Other abstract tables containing interesting particulars in regard to extremes of temperature and variations of temperature it is proposed also to add.

These meteorological reductions, with the magnetical reductions from 1865 to 1882, spoken of in the last report, it is intended to publish in a separate form, similar to that of the twenty years' meteorological reductions some years ago.—*March 6th*, 1893.

ROYAL OBSERVATORY, EDINBURGH.—Ralph Copeland, Ph.D., F.R.A.S., Astronomer Royal for Scotland.

The meteorological work of the Royal Observatory, Edinburgh, in 1892 consisted, as in former years, principally of computing the observations made at 55 of the Scottish Meteorological Society's stations, and preparing monthly and quarterly abstracts and reports for the use of the Registrar-General for Scotland.

The monthly schedules have been sent in with the usual regularity, the average monthly number received having been 50·4. This completes the 37th year of these reports.

The daily readings of barometer and thermometers at the Observatory have been continued. The rainfall has been collected in two gauges—the old one on the roof of the building, and the new one on the grass; the latter having been established in January 1891. Both are 5 inches in diameter. The difference in the rainfall, as shown by the two gauges, amounts to as much as 7·964 ins. in the year, as a mean of the two years' observations, or 0·346 in. per foot of difference of height.—*February 6th*, 1893.

THE KEW OBSERVATORY OF THE ROYAL SOCIETY, RICHMOND, SURREY.—G. M. Whipple, B.Sc., Superintendent.

During the year an additional story has been added to the west wing of the Observatory. The cost of the operations being a heavy charge on the funds at the present disposal of the Committee, they made application to the Royal Society for a loan of £400, which was granted. During the building alterations the thermometer testing was carried on in the experimental magnetic house.

The several self-recording instruments for the continuous registration of atmospheric pressure, temperature, and humidity, wind (direction and velocity), bright sunshine, and rain, have been maintained in regular operation throughout the year, and the standard eye observations for the control of the automatic records duly registered.

Experiments have been for some months in progress upon the spare Beckley rain gauge with Willesden prepared paper and aniline ink, with the view of determining its adaptability for use with that instrument as a substitute for the paper hitherto used, which was found to deteriorate on keeping. Daily trials were carried out, and the results showed a marked improvement upon those previously obtained with the ordinary paper. It was found impossible, however, to entirely prevent the lengthening of the papers during very damp weather, although the sheets were soaked and coated with various varnishes, &c. The experiments are still in progress.

The electrograph was kept in action until the end of July, when it was dismounted to prevent possible damage during the building operations. Its scale value was determined by direct comparison with the portable electrometer, No. 53, early in May and at the end of June. On the completion of the building, the instrument being in a somewhat inconvenient spot, rendering dislocation possible, it was decided to remove it to a safer position, which was made accessible by alterations to the thermograph room. The water reservoir, however, was not moved, as this might perhaps have interfered with the local continuity of the records, and it is intended to recommence the regular records with the beginning of 1893.

Operations connected with cloud photography have been suspended during the year.

With the view of insuring greater uniformity in the observation of fog and mist a list of twenty-four well known objects in the neighbourhood of the Observatory has been prepared, at distances varying from 9 to 3,850 yards. Since May the most distant of the objects visible at each observation hour between sunrise and sunset has been noted. Up to the present the most dense fog recorded was when an object at 20 yards was obscured.

Further experiments were made at the beginning of the year with Munro's sight indicating anemometer, but the variation in the viscosity of the oil at low temperatures has caused some difficulty in determining the scale value of the instrument, which has been returned to the maker.

The serious illness of Mr. Whipple prevented his performing the duties of Superintendent during the latter half of the year, but the Committee are glad to state that the routine work of the Observatory has not suffered in consequence.—*January* 1893.

RADCLIFFE OBSERVATORY, OXFORD.—E. J. Stone, F.R.S., Radcliffe Observer.

The following is a report on the meteorological work of this Observatory for the year 1892:—

The observations have been made on the same general plan as in former years. The photographic self-registering instruments have worked satisfactorily throughout the year; they have been cleaned as usual, but have not required any repairs, beyond the fitting of new clips to the thermograph cylinder. On October 8th the anemograph was cleaned by Mr. Munro, who found the working parts considerably worn, and it is proposed to mount a new anemograph; there have, however, been no failures of registration since that date.

The argentic gelatino-bromide paper has been used for the photographic records throughout the year.

Weather reports have been sent, as in previous years, daily (by telegram) to the Meteorological Office; monthly to the Registrar-General and local newspapers; yearly to Symons's *British Rainfall*: meteorological information has also been supplied to the Chief Engineer of the London County Council; to the Chief Engineer to the Oxford City Council; to Mr. G. A. Sworn, M.A., Balliol, for his experiments on the expansion and absorption of gases; and to others by request. Mr. M. S. Pembrey, M.A., has carried on some hygrometrical experiments at the Observatory during frost. The eye observations, the rainfall and sunshine records, are reduced to date, and have been printed in the publications of the Meteorological Council and in the local newspapers.

The mean temperature of the air for the year 1892 was 47°·3, being 1°·0 below the average for the last 37 years. The total registered amount of bright sunshine was 1,495 hours. The maximum temperature for the year was 81°·6 on July 3rd. The minimum was 13°·7 on December 27th, whilst the lowest on the grass on the same day was 6°·8. During the period of continued frost, December 23rd, 1892, to January 7th, 1893, the mean temperature of the air was as low as 25°·9. The total rainfall for the year was 20·756 ins., being 5·661 ins. less than the average for the last 77 years: this deficiency occurred in the first six months, and the greatest departure from the monthly mean occurred in January, when the rainfall was 1·502 in. below the mean for the last 77 years. Displays of Aurora Borealis were observed on April 25th and August 12th.

In September Mr. F. Bellamy was appointed as assistant at the University Observatory: his post has been filled up by the appointment of Mr. E. McClellan.—*February 6th*, 1893.

On the relation between the duration of Sunshine and amount of Cloud, and the height of the Barometer, as determined from observations made at the Royal Observatory, Greenwich, during the years 1877 to 1891.

By WILLIAM ELLIS, F.R.A.S.,

Of the Royal Observatory.

(Plate VII.)

[Received December 21st, 1892—Read February 15th, 1893.]

This question has been before dealt with in a paper contributed by Mr. Whipple to the *Quarterly Journal* of the Society, Vol. V. page 218, in which he employed the records and observations of the Kew Observatory. The discussion was based on the sunshine records of the two years 1877 and 1878, and the cloud observations of the ten years 1869 to 1878, including all available results for the years 1874 to 1878, supplemented only by results corresponding to high and low barometer readings during the years 1869 to 1873, the number of days of high and low barometer reading in the years

1874 to 1878 not having been considered to be sufficiently numerous to afford a good determination at the extreme ends of the barometric scale.

Mr. Whipple found that the duration of sunshine was greatest, and the amount of cloud least, when the barometer stood at about 30·2 ins., the duration of sunshine being less and the amount of cloud greater both at lower and higher barometer readings, the decrease of sunshine and increase of cloud being especially rapid with increase of barometer reading[1] above 30·2 ins. In the tabulation, the daily proportion of sunshine (constant sunshine = 100) and amount of cloud, formed into groups with relation to the height of the barometer, were not separated as regards months of the year. Indeed, having only two years of sunshine records with which to deal the material available was not sufficient to permit of any useful tabulation in separate months, so that no other course than that followed could at the time have well been pursued. But regarding the result arrived at, and especially the apparently sunless condition indicated as existing with high barometer, there seemed to be reason to think that the combination together of different months of the year had affected the result in a way that was probably hardly anticipated. As is well known, the duration of sunshine is very much smaller in winter than in summer, because of the lower altitude attained by the sun in winter, and the more cloudy condition of the sky at that period of the year. But it happens also that the range of the barometer is much greater in winter than in summer, both rising higher and falling lower in the winter period of the year, in consequence of which the values of sunshine tabulated with high and low readings of the barometer consist principally of winter, that is small values, of sunshine, whilst with medium heights of the barometer summer values of sunshine, that is large values, preponderate. Consequently, in combining together different months of the year, values of sunshine accompanying high and low barometer, that is winter or small values, become contrasted with values at medium heights of the barometer that include summer, or large values, as well as winter values, so that the combined curve thus found may not be really conterminous.

I had long desired to reinvestigate this question, making separation of the results for different months of the year, in order to ascertain to what extent the causes above mentioned might have influenced the result obtained; and as soon as records for fifteen years had been accumulated at the Royal Observatory, that is from 1877 to 1891, a discussion of the same was commenced, but the work has proved much more tedious, and has consumed a much greater amount of time, than was expected.

The daily duration ~~of~~ sunshine as recorded at Greenwich in the fifteen months of January, 1877 to 1891, being tabulated with the corresponding daily mean height of the barometer, arranging the values according to height

[1] It does not appear to be stated whether the barometer readings are reduced to sea level, but since the height above sea level is said to be 34 feet only, the difference which omission of such correction would produce, as regards comparison of the results with those of the present paper, is not material.

MEAN DAILY HEIGHT OF THE BAROMETER, WITH THE CORRESPONDING MEAN DAILY DURATION OF SUNSHINE, PROPORTION OF SUNSHINE, AND MEAN DAILY AMOUNT OF CLOUD, AS DEDUCED FROM THE OBSERVATIONS AND RECORDS AT THE ROYAL OBSERVATORY, GREENWICH, IN THE YEARS 1877–1891.

No. of days employed.	Mean height of Barometer reduced to Mean Sea Level.	Sunshine. Mean daily duration of Sunshine.	Sunshine. Proportion of Sunshine (constant sunshine = 1).	Mean Daily Amount of Cloud 0–10.	No. of days employed.	Mean height of Barometer reduced to Mean Sea Level.	Sunshine. Mean daily duration of Sunshine.	Sunshine. Proportion of Sunshine (constant sunshine = 1).	Mean Daily Amount of Cloud 0–10.
	January.					**February.**			
	ins.	hours.				ins.	hours.		
52	29·281	0·9	0·104	7·99	47	29·314	1·2	0·127	8·03
51	·625	1·5	0·173	6·67	47	·630	1·3	0·130	7·90
52	·828	0·6	0·069	7·34	47	·801	1·9	0·193	7·25
52	29·990	0·6	0·069	7·68	47	29·938	1·2	0·121	7·93
51	30·086	0·8	0·097	7·49	47	30·048	0·9	0·093	8·19
52	·209	1·0	0·119	7·42	47	·154	1·8	0·179	7·52
52	·318	1·2	0·143	6·22	47	·268	1·4	0·138	7·24
51	·452	1·0	0·122	7·73	47	·414	1·6	0·167	7·48
52	30·636	0·5	0·060	7·80	47	30·613	2·5	0·253	5·41
	March.					**April.**			
	ins.	hours.				ins.	hours.		
52	29·288	2·4	0·204	8·03	50	29·390	2·6	0·193	8·16
51	·567	2·7	0·224	7·44	50	·583	2·9	0·213	7·93
52	·755	2·3	0·190	7·66	50	·689	3·9	0·277	7·37
52	·868	2·8	0·237	7·17	50	·805	3·3	0·242	7·66
51	29·991	3·1	0·264	6·45	50	·878	3·9	0·282	7·06
52	30·048	2·5	0·213	7·29	50	29·931	3·8	0·277	7·31
52	·156	3·2	0·271	6·38	50	30·024	4·7	0·337	6·41
51	·285	4·1	0·346	6·26	50	·113	5·3	0·386	5·90
52	30·474	4·1	0·351	5·03	50	30·284	5·9	0·428	5·20
	May.					**June.**			
	ins.	hours.				ins.	hours.		
52	29·515	3·6	0·233	8·04	50	29·645	4·1	0·247	8·29
51	·665	3·5	0·228	8·00	50	·791	3·9	0·239	7·61
52	·778	5·3	0·345	6·77	50	·858	4·7	0·283	7·68
52	·853	5·3	0·339	7·12	50	·920	4·9	0·295	7·37
51	29·918	5·4	0·345	6·87	50	29·994	5·5	0·336	6·79
52	30·018	5·6	0·358	6·56	50	30·029	6·2	0·374	6·65
52	·106	7·0	0·445	5·30	50	·118	7·6	0·461	5·29
51	·204	6·0	0·386	6·00	50	·173	7·2	0·434	5·45
52	30·387	9·5	0·616	3·28	50	30·279	8·0	0·483	4·53

of barometer, they were then divided into nine equal groups, or into groups as nearly equal as possible, thus giving to each practically equal weight. Similarly for each of the other months of the year. A like grouping was made of the daily proportion of sunshine, that is the fraction which represents the daily amount, taking constant sunshine = 1. And as usefully illustrating the subject, a grouping of the daily amount of cloud was also made, as depending on observations taken usually at 9 a.m., noon, 3 p.m.,

MEAN DAILY HEIGHT OF THE BAROMETER, WITH THE CORRESPONDING MEAN DAILY DURATION OF SUNSHINE, PROPORTION OF SUNSHINE, AND MEAN DAILY AMOUNT OF CLOUD, AS DEDUCED FROM THE OBSERVATIONS AND RECORDS AT THE ROYAL OBSERVATORY, GREENWICH, IN THE YEARS 1877–1891—*Continued.*

No. of days employed.	Mean height of Barometer reduced to Mean Sea Level.	Sunshine. Mean daily duration of Sunshine.	Sunshine. Proportion of Sunshine (constant sunshine = 1.)	Mean Daily Amount of Cloud 0–10.
	July.			
	ins.	hours.		
52	29·542	3·3	0·208	8·18
51	·720	4·2	0·265	8·05
52	·816	3·8	0·238	8·13
52	·894	5·0	0·309	7·57
51	29·922	4·4	0·274	7·53
52	30·019	5·5	0·344	6·94
52	·061	6·2	0·389	6·21
51	·136	7·3	0·456	5·30
52	30·257	8·3	0·517	4·41
	August.			
	ins.	hours.		
52	29·551	3·9	0·270	7·67
51	·711	4·2	0·292	7·82
52	·801	3·8	0·265	7·52
52	·880	4·8	0·328	7·13
51	29·922	4·6	0·313	6·84
52	30·007	5·4	0·372	6·09
52	·038	5·4	0·372	6·45
51	·111	6·2	0·426	5·27
52	30·212	6·2	0·418	5·13
	September.			
	ins.	hours.		
50	29·527	2·9	0·234	7·67
50	·727	3·2	0·252	7·40
50	·856	3·1	0·247	7·33
50	29·942	2·9	0·230	7·51
50	30·015	3·6	0·284	6·47
50	·091	3·7	0·296	6·50
50	·154	5·3	0·420	4·69
50	·221	5·1	0·409	4·93
50	30·361	5·3	0·422	4·54
	October.			
	ins.	hours.		
52	29·322	1·8	0·171	7·93
51	·582	2·3	0·217	6·70
52	·727	1·9	0·183	7·46
52	·829	2·2	0·209	7·08
51	29·944	2·7	0·251	6·83
52	30·061	2·5	0·239	6·69
52	·166	3·4	0·323	5·76
51	·268	2·8	0·262	6·46
52	30·436	3·3	0·311	5·14
	November.			
	ins.	hours.		
50	29·242	1·4	0·165	7·13
50	·489	1·3	0·143	7·17
50	·688	1·5	0·173	6·70
50	·803	1·5	0·166	7·09
50	29·915	1·7	0·191	6·73
50	30·034	1·4	0·163	6·79
50	·162	1·5	0·168	6·80
50	·296	1·3	0·151	7·31
50	30·475	1·2	0·132	7·46
	December.			
	ins.	hours.		
52	29·343	0·9	0·115	7·46
51	·590	0·7	0·093	7·32
52	·749	0·5	0·065	7·26
52	·864	0·7	0·086	7·34
51	29·969	0·8	0·097	7·23
52	30·085	0·8	0·103	6·94
52	·241	0·6	0·078	7·22
51	·387	0·6	0·082	7·84
52	30·557	0·5	0·067	7·57

and 9 p.m. daily. In this discussion the results on every day throughout the fifteen years have been employed, no result having been either omitted or rejected. In months of 31 days there were, in 15 years, 465 day available, so that the groups include records for either 51 or 52 days; in months of 30 days 450 days were available, so that each group consists of 50 days; and in February, giving 423 days, each group contains 47 days. The barometer values in each month increase by unequal intervals, but this is in no way

detrimental. Had the results been grouped according to equal intervals of barometer reading, the higher and lower positions would have been very imperfectly represented, as compared with the middle positions, that is they would not have had the same weight.

The results arrived at are given in the annexed table (pp. 120 and 121), and are also exhibited graphically in Plate VII.

An inspection of the table, or, which is better, of the graphical representation, shows at once that each month has its own special peculiarity in the relation of sunshine and cloud to height of barometer. The variation in the duration of sunshine and in the proportion of sunshine is in each month in close correspondence with the variation in the amount of cloud; increase of sunshine being accompanied by decrease of cloud. In the winter months, November, December, and January, there is little difference in the duration of sunshine or amount of cloud at different heights of the barometer, if anything, there is a tendency to less sunshine and more cloud with high barometer, the irregularities that occur in the curves appearing evidently to be due to still insufficient number of observations. In February there is continuous increase in duration of sunshine with rise of barometer, and corresponding continuous decrease in amount of cloud. These tendencies become greater and more pronounced in each month as the summer is approached, and lessen again towards autumn, until in October a phase is reached corresponding to that experienced in February, and then comes again the dull uniform winter. It will be especially remarked that, neglecting petty irregularities, the tendency of any one monthly curve is always to progress in the same direction, in winter slightly upwards, in other parts of the year continuously downwards to a lesser or greater extent. In no case is there a downward progress of the curve with an upward turn at the end, but in every month progress is in one direction only. It will be evident from the graphical representation how combination of the different months of the year would produce a curve that is disproportionate, that is to say, the sunless winter periods at high barometer not being balanced by any corresponding summer values, an annual curve would result having a sharp upward bend from about barometer reading 30·2 ins., one not representing any physical fact, since a like condition is not experienced in any month of the year.

One result of the present inquiry is to show that, in the months from February to October, there is on the whole distinct indication of increased sunshine and correspondingly less cloud with increase of barometer reading, the increase of sunshine with increased barometer reading being, in the months from April to September, especially marked. The winter in all conditions of the barometer is uniformly dull. The conclusion is of course a general one. It might be interesting to group results of this kind with respect also to different winds, but a period of fifteen years is one probably altogether too short on which to found so extended an inquiry. But it is evident, on the whole, that high barometer in summer presages increased sunshine, that the effect is less pronounced in early spring and late autumn, and that it becomes slightly reversed in winter.

DISCUSSION.

Mr. Tripp remarked that he had heard it said that there was much more sunshine on the western side of London than on the eastern side. He would like to know whether this was actually the case.

Mr. Scott said that having recently discussed the sunshine observations in the British Isles during the period 1881-90, he was able to say that the difference between the sunshine registered on the eastern and western sides of London, as represented by Greenwich and Kew, was slight, Kew only being a few per cent. in excess of Greenwich.[1] It was principally a question of wind direction, an Easterly wind bringing dull weather from smoke to Kew and bright weather to Greenwich. The absence of sunshine during the prevalence of high barometer readings in winter was due to the fact that at that period of the year high pressures were usually accompanied with fog.

Mr. Chatterton said that he considered that Mr. Ellis's diagram was very interesting and one of the most perfect that had been placed before the Society; its complete agreement with the table given in the paper was easily seen.

Mr. Harries said that it had occurred to him to compare the duration of sunshine in and around the Metropolis with that registered at some station beyond the influence of London smoke and fogs, to see whether the conclusions arrived at by Mr. Ellis for Greenwich were, or were not, generally applicable. The diagram which he exhibited represented by curves the barometer at the Royal Observatory and the total duration of sunshine in the western half of London, at Greenwich, and at Glynde Place, Lewes, for each week of the year 1892. Although Lewes had 344 hours and Western London 78 hours more than Greenwich (1,274 hours) for the 52 weeks, a very good agreement existed between the curves of the three records. At the beginning and end of the year the sunshine in each locality varied inversely, and during, spring, summer, and autumn directly, as the barometer, thus strongly confirming the results shown in the paper under discussion.

Mr. C. Harding thought that Mr. Ellis had exhibited considerable ingenuity in dealing with the figures, as by taking groups of equal number of observations all the results were made strictly comparable. The range of the winter curves was due to the storms experienced at that season of the year.

Mr. Dines said that he was rather surprised when he saw the results arrived at by Mr. Ellis, for he had thought that a high barometer in winter would be associated with even less sunshine than Mr. Ellis had given, as he had formed an opinion that the sun usually became invisible on account of fog when the pressure rose much above 30·2 ins. The amount of fog was, however, greatly influenced by locality, for he had found that at his present residence, which was three miles further from the river Thames than where he formerly lived, the weather was frequently bright and sunny when there was a thick fog in the neighbourhood where he had previously resided.

Mr. Dymond thought that the results of Mr. Ellis's investigation would have had more value if some inland or sea-coast station quite out of the influence of London smoke had been chosen rather than Greenwich.

Mr. Symons considered it needless to carry out the mean amount of cloud to two places of decimals.

The President (Dr. Williams) said that when looking through the figures he had been much impressed with the small amount of sunshine which the British Islands received, and yet somehow or other we managed to get on very well, and to produce a good deal of intellectual and manual labour. In Colorado, where he had recently been, there were 330 days of sunshine every year, and it was sunshine of a most brilliant character.

Mr. Ellis said that in regard to the difference in amount of sunshine between the eastern and western sides of London, Mr. Scott had already explained. It was largely a question of direction of wind. The effect of fog at Greenwich in winter in relation to sunshine he (Mr. Ellis) thought to be overrated. Attention had naturally been drawn to this point when preparing the paper, but no allusion had been made thereto, since the influence of fog on sunshine on the summit of

[1] The precise figures are that for the 10 years Kew received, in all, 13,991 hours of sunshine, and Greenwich 12,469, so that the difference is about 11 per cent.

Greenwich hill (more than 150 feet above sea level) was not great, the days of fog in mid-winter, including those of moderate fog, averaging only about five per month. The weather was frequently bright and clear at the Observatory when the lower ground was enveloped in fog; the tendency of the curves in autumn and spring, when little fog (by day) exists, would also lead to the inference that the mid-winter curves should be much as the diagram shows. As respects the giving the amount of cloud to two decimals, it is always well to consider the amount of variability of an element, and as, in winter, the variation in the amount of cloud is only a small percentage of the mean amount, two decimals may with propriety be given. Mr. Whipple did the same.

REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1892.

By EDWARD MAWLEY, F.R.Met.Soc., F.R.H.S.

(Plate VIII.)

[Read February 15th, 1893.]

The number of observers remains much the same as in the previous year, viz. 107, as against 105 in 1891. Observations were not received for the present Report from Torquay and Wells in District **A.**; from Rochester, Cobham, Devizes, Lambourne, and Hampstead in District **C.**; from Burford and Melton Mowbray in District **D.**; from Saffron Walden in District **E.**; from Rochdale and Ramsey in District **F.**; from Penpont in District **H.**; and from Ulceby and Hexham in District **I.** On the other hand, returns were sent in from the following new Stations:—Newport (Bassaleg), Chepstow (St. Arvans), and Aberystwith in District **A.**; Blandford, Horsham (Muntham), Dover, Tunbridge Wells, Farnborough, Beckenham, Farnham (Churt), Leatherhead (Oxshott), and Reading in District **C.**; Hereford (Breinton), Henley-in-Arden, Hinckley, and Retford (Eaton) in District **D.**; Collon and Londonderry (Ballynagard) in District **G.**; Gateshead-on-Tyne (Low Fell) in District **I.**; and Aberdeen in District **J.** At the present time there is not a single District altogether unrepresented, but the Society has as yet unfortunately only one Phenological Observer in either Scotland East or Scotland North.

New observers are still especially wanted in Ireland, the north-east of England, also in the east and north of Scotland.

As far as I have been able to test the accuracy of the observations they appear to have been taken in most cases with considerable care and in the most satisfactory manner. Here and there, however, there are indications that the flowering of "the same individual trees, shrubs and plants growing in the same spots," observed in 1891, were not noted last year; while in others the opening of the first blossoms seems to have been missed.

Although such careless and misleading entries are quite the exception, I cannot too frequently or too strongly impress on observers generally the necessity of following implicitly the few simple instructions printed on the forms; for it is only observations made in accordance with these simple, but important, rules that can be regarded as of any real value to the recorder.

I much regret that I have been unable as yet to obtain any satisfactory mean dates for the Tables of Birds and Insects, I can only say that I shall feel greatly indebted to any Fellow of the Society who may be able to supply me with copies of any fairly long records of the first appearances of any of the birds and insects mentioned in those Tables.

The Winter of 1891-92.

Taken as a whole, December proved a mild winter month in very nearly all parts of the British Isles: notwithstanding a rather sharp frost which set in shortly before Christmas and lasted about a week. January, on the contrary, was very cold in all districts, the departures in mean temperature from the average varying from—2°·3 in the east of Scotland to—3°·8 in the south of Ireland. There was a marked contrast between the weather of the first fortnight in February and that of the rest of the month, the former being very mild, while the latter half remained as unseasonably cold.

The frost at Christmas, following a long spell of mild weather, came upon vegetation very suddenly, and when the ground had been for many weeks saturated with rain. Fortunately it was only in the Midlands and in Scotland that the cold proved sufficiently severe to do more than bring everything at once to a standstill. During the first half of January there occurred another brief frost, which was keener than the previous one; while the third and last frost of the winter took place soon after the middle of February. This proved the sharpest of the three, the cold being keenly felt throughout Scotland and in the north, east, and midland counties of England. The winter of 1891-2 must therefore be regarded as having been a cold, but somewhat fitful one. But, unlike most fitful winters, at such regular intervals were the frosts distributed over it, that there were few localities where the ground at any time became warm enough to start plants into dangerous growth. Owing to the wetness of the soil in the early part of the winter, and the frequent frosts afterwards, farming operations were considerably retarded.

The hazel, taking the country generally, was from about a week to a fortnight later in coming into flower than the adopted averages for the different districts, but on the other hand from a few days to a week earlier than in the previous winter.

The song thrush was first heard nearly a week earlier than in 1891. The honey bee first visited flowers a few days later than in the previous year.

Observers' Notes.

DECEMBER, 1891.—*Pennington* (C.). No holly-berries this winter. *Addlestone* (C.). 16th. Until injured by last night's frost, violets, cranebills, &c., still remained in flower.

JANUARY, 1892. *Sidcot* (A.). 21st. A nest of starlings seen. *Aberystwith* (A.). 3rd. Many kittiwakes drifted ashore, having been beaten down into the

LIST OF OBSERVERS.

District and Station.	County.	Height above sea-level.	Observer.
A.		Ft.	
Penzance (Marazion)	Cornwall	40	F. W. Millett
Falmouth	Cornwall	190	Miss R. Barclay
Liskeard	Cornwall	400	S. W. Jenkin, C.E.
Tiverton	Devon	270	Miss M. E. Gill
Bideford (Westward Ho)	Devon	100	H. A. Evans
Bideford (Instow)	Devon	250	H. M. W. Hinchliff
Axbridge (Sidcot)	Somerset	260	E. G. Aldridge, F.R.Met.Soc.
Axbridge (Sidcot)	Somerset	200	W. F. Miller
Bristol (Clifton)	Gloucester	300	G. C. Griffiths, F.E.S.
Bristol (Clifton)	Gloucester	250	R. M. Prideaux
Cardiff (Penarth)	Glamorgan	120	G. A. Birkenhead
Cardiff	Glamorgan	40	A. Pettigrew
Cardiff (Castleton)	Glamorgan	80	F. G. Evans, F.R.Met.Soc.
Newport (Bassaleg)	Monmouth	25	W. J. Grant
Chepstow (St. Arvan's)	Monmouth	360	Miss Mabel Peake
St. Davids	Pembroke	220	W. P. Propert, LL.D., F.R.Met.Soc.
Aberystwith	Cardigan	30	J. H. Salter, B.Sc.
B.			
Killarney	Kerry	100	Ven. Archdeacon Wynne, F.R.Met.Soc.
Wicklow	Wicklow	10	Miss S. S. Wynne
C.			
Charmouth (Whitchurch Canonicorum)	Dorset	150	Miss Mules; W. Rendall
Blandford	Dorset	270	J. C. Mansell-Pleydell, F.G.S., F.L.S.
Wincanton (Buckhorn Weston)	Dorset	290	Miss H. K. H. D'Aeth
Lymington (Pennington)	Hants	100	Miss E. S. Lomer
Winchfield (StrathfieldTurgiss)	Hants	200	Rev. C. H. Griffith
Hastings (Bexhill-on-Sea)	Sussex	10	H. Le Mesurier Dunn
Horsham (Muntham)	Sussex	250	Percy S. Godman, F.Z.S.
Dover	Kent	..	F. D. Campbell
Tunbridge Wells	Kent	340	Miss E. A. Scott
Canterbury	Kent	50	Dr. J. Reid
Sittingbourne (Lynsted)	Kent	140	R. M. Mercer, F.R.Met.Soc.
Farnborough	Kent	350	F. G. Minchin Kelly
Beckenham	Kent	150	C. H. Hooper
Ewhurst (Coneyhurst)	Surrey	600	J. Russell
Farnham (Churt)	Surrey	350	Rev. A. W. Watson
Cranleigh (Winterfold)	Surrey	580	R. Turvey
Cranleigh (Willinghurst)	Surrey	400	A. Nash
Leatherhead (Oxshott)	Surrey	210	W. H. Dines, B.A., F.R.Met.Soc.
Weybridge (Addlestone)	Surrey	100	C. U. Tripp, M.A., F.R.Met.Soc.
East Molesey	Surrey	40	Mrs. M. S. Jenkyns
Salisbury	Wilts	150	E. J. Tatum
Marlborough	Wilts	480	E. Meyrick, B.A., F.Z.S.
Reading (Whitchurch)	Oxford	150	Rev. J. Slatter, M.A., F.R.Met.Soc.
Henley-on-Thames	Oxford	500	H. Goadby
Reading	Berks	..	H. Goadby
D.			
Oxford	Oxford	200	F. A. Bellamy, F.R.Met.Soc.
Cheltenham	Gloucester	250	M. L. Evans
Tewkesbury (Beckford)	Gloucester	120	F. Slade, F.R.Met.Soc.
St. Albans	Herts	300	Miss E. F. Smith
St. Albans	Herts	380	H. Lewis
Berkhamsted	Herts	400	Mrs. E. Mawley
Harpenden	Herts	370	J. J. Willis
Ross	Hereford	210	H. Southall, F.R.Met.Soc.
Hereford (Breinton)	Hereford	230	H. A. Wadworth, F.R.G.S.
Evesham	Worcester	120	Rev. D. Davis, B.A.

LIST OF OBSERVERS—*Continued.*

District and Station.	County.	Height above sea-level.	Observer.
D.		Ft.	
Henley-in-Arden	Warwick	320	T. H. G. Newton, F.R.Met.Soc.
Northampton	Northampton	320	H. N. Dixon, M.A., F.L.S.
Churchstoke	Montgomery	550	P. Wright, F.R.Met.Soc.
Hinckley	Leicester	430	C. C. Hurst, F.R.H.S.
Thurcaston	Leicester	250	Rev. T. A. Preston, F.R.Met.Soc.
Uppingham	Rutland	300	G. W. S. Howson, M.A.
Walsall	Stafford	450	W. F. Blay, F.R.Met.Soc.
Burton-on-Trent	Stafford	150	J. E. Nowers
Stoke-on-Trent (Tean)	Stafford	470	Rev. G. T. Ryves, F.R.Met.Soc. M. G. B. Ryves
Beeston	Notts	210	G. Fellows, F.R.Met.Soc.
Worksop (Hodsock)	Notts	60	Miss Mellish, F.R.H.S.
Retford (Eaton)	Notts	..	J. Cordeaux
Bakewell	Derby	400	Miss E. Taylor
Macclesfield	Derby	500	J. Dale
Grantham (Belton)	Lincoln	200	Miss F. H. Woolward
Huddersfield	Yorkshire	800	S. L. Mosley
Harrogate	Yorkshire	340	J. Farrah
E.			
Hertford	Herts	140	W. Graveson
Hitchin	Herts	230	J. E. Little, M.A.
Braintree	Essex	240	H. S. Tabor, F.R.Met.Soc.
Colchester (Lexden)	Essex	90	Miss Carver
Ipswich (Sproughton)	Suffolk	30	Rev. A. Foster-Melliar
Wymondham (Tacolneston)	Norfolk	190	Miss E. J. Barrow
Wryde	Northampton	10	S. M. Egar
F.			
Chester	Cheshire	..	G. P. Miln
Parkgate (Heswall)	Cheshire	160	F. M. Sherwood
Caton (Claughton)	Lancashire	80	Mrs. Kent Green
Settle	Yorkshire	500	S. S. Burlingham Miss F. P. Thompson
Settle (Giggleswick)	Yorkshire	500	E. Peake, M.A.
Ambleside	Westmoreland	320	S. A. Marshall
Egremont	Cumberland	160	J. Sherwen
Douglas	I. of Man	150	H. S. Clarke, F.E.S.
Orry's Dale	I. of Man	70	Miss C. G. Crellin
G.			
Edgeworthstown	Longford	270	J. M. Wilson, B.A.
Drogheda (Collon)	Louth	450	Miss E. C. Wynne
Loughbrickland	Down	350	Rev. H. W. Lett, M.A.
Saintfield	Down	310	Rev. C. H. Waddell, M.A.
Antrim	Antrim	70	Rev. W. S. Smith
Londonderry	Londonderry	450	T. Gibson
Londonderry (Ballynagard)	Londonderry	30	Miss A. M. Campbell
H.			
Dalry (Dalshangan)	Kirkcudbright	500	T. R. Bruce
Tynron	Dumfries	520	J. Shaw
Thornhill	Dumfries	300	J. Fingland
Jardington	Dumfries	100	J. Rutherford
Helensburgh	Dumbarton	100	Miss Muirhead
I.			
Doddington	Lincoln	90	Rev. R. E. Cole
Driffield	Yorks (E. R.)	80	J. Lovel, F.R.Met.Soc.
Thirsk	Yorks (N. R.)	120	A. B. Hall
Darlington (East Layton)	Yorks (N. R.)	570	Mrs. E. O. Maynard Proud
Durham	Durham	350	H. J. Carpenter
Gateshead-on-Tyne (Low Fell)	Durham	90	A. W. Price
J.			
Aberdeen	Aberdeen	40	P. Harper
K.			
Garve (Inverbroom)	Ross	50	J. A. Fowler

sea and drowned by the late rough weather. 9th. Larks and starlings in one continuous stream passed southward along the coast all day. Fieldfares first seen here this winter. 25th. Winter aconite in flower. *Killarney* (B.). 29th. Lesser celandine in flower. *Wicklow* (B.). 8th. Tropæolums and the last of the chrysanthemums killed by frost. *Pennington* (C.). 23rd. Spurge laurel in flower. *East Molesey* (C.). 18th. Great tit heard. *Berkhamsted* (D.). 25th. Winter aconite in flower. *Harrogate* (D.). Moles very active. 28th. Missel thrush first heard. *Lexden* (E.). 30th. Winter aconite in flower. *Tacolneston* (E.). 28th. Missel thrush first heard. 30th. Lesser celandine in flower. *Inverbroom* (K.). 28th. Rapid thaw of snow, occasioning unprecedented damage to bridges, roads, river banks and land.

FEBRUARY.—*Falmouth* (A.). The blackberry leaves still remain uninjured except in very exposed places. *Sidcot* (A.). 9th. Greater stitchwort in flower. 15th. The coltsfoot had a bud upon it partially unfolded; but owing to the severe weather which followed, this bud did not open until eight days afterwards. *Aberystwith* (A.). 12th. Missel thrush first heard. 13th. Frogs spawning. 23rd. Lesser celandine in flower. 24th. Blackbird first heard. *Wicklow* (B.). Early in the month the garden was a blaze of crocuses, siberian squills, snowdrops, hepaticas, &c. 15th. Heaviest fall of snow since 1880, and much mischief was done in the garden, all the wall-flowers killed, also many delicate plants, such as calceolarias, geraniums, &c., which had survived the previous frosts. *Pennington* (C.). 24th. Lesser celandine in flower. *Canterbury* (C.). The catkins of the hazel were destroyed by severe frost which occurred during the latter part of the month. *Coneyhurst* (C.). 16th. 20° of frost cut bushes of berberis. Darwinii that had stood through the winter of 1890-1 as if they had been scorched by fire, nearly every leaf being killed. *Winterfold* (C.). Soft-wooded plants suffered more this winter than in that of 1890-1, especially strawberries. *Addlestone* (C.). After the December frost had gone out of the ground there were few weeks when ploughing, sowing, &c. could not be proceeded with. *Cheltenham* (D.). A great number of redwings about here this winter, but hardly any fieldfares. The frost following a very wet autumn has had a very disastrous effect on garden flowers and vegetables. *Northampton* (D.). 26th. Daphne mezereum in flower. *Hinckley* (D.). 27th. Rooks began to build. *Hodsock* (D.) Sweet bays, summer flowering yellow jasmine, banksia roses, &c. have suffered more this winter than they did last. *Harrogate* (D.). 6th. Blackbird first heard. 10th-12th. The bright sunshine has caused caddis worms to appear on the stones in the brooks. 28th. Three-fourths of the arable land is yet unploughed. Daphne mezereum in flower. Pastures are very bare and look sickly. This I attribute to the heavy rainfall in December saturating our cold clay soil, and the severe frosts which have since followed. *Sproughton* (E.). 9th. Blackbird first heard. *Orry's Dale* (F.). 13th. Celandine in flower. *Antrim* (G.). 14th. Antirrhinums and stocks, which had stood unharmed during the previous part of the winter, have been now killed. *Dalshangan* (H.). 19th. The frost has killed outright clematis Jackmanii, and half killed escallonia and garya elliptica and even Ayrshire roses. *Tynron* (H.). 6th. Missel thrush heard. *Driffield* (I.). Turnip crop greatly injured, chiefly by the frosts in the week preceding Christmas, when the ground was unprotected by snow. 19th. Intense frost; a winter jasmine on a south wall had all its flowers killed. *Durham* (I.). 20th. Partridges pairing. *Low Fell* (I.). 19th. Privet hedge browned by frost. *Inverbroom* (K.). The severest winter experienced for sheep stocks on the hills probably for 40 years. Vegetation started during the early part of February, but was cut back by the severe frost which followed.

The Spring.

The weather of the first spring month was very cold everywhere, and especially so in the southern, midland, and eastern counties of England, and in the south of Ireland; in which districts the mean temperature was from 4°·2 to 4°·6 in defect of the average. April also proved somewhat cold. On the other hand May was moderately warm in nearly all parts of the country. It will thus be seen that the spring quarter was on the whole an unusually

cold and backward season. There was, moreover, a very deficient rainfall, while the duration of bright sunshine was much in excess of the mean for the quarter.

Throughout March and April and during the early part of May the weather continued so dry and winterly that early vegetation made scarcely any progress at all. The pastures remained everywhere particularly bare, consequently farmers were again at a loss to find sufficient green food for their cattle and sheep. The land, however, as in the previous spring, was in such splendid condition for working, that spring corn and other seeds were got into the ground with little labour and under the most favourable circumstances. Even on heavy lands the drought and frost had given the soil a deep and mellow tilth. After the first week in May the weather became more genial, and later in the month some welcome and abundant warm rains arrived which started everything into rapid growth so that the whole face of the landscape became suddenly changed. In Ireland especially the luxuriant growth of all crops about this time is said to have been quite remarkable.

The fruit blossom was again abundant, but in most places much of it was injured by late spring frosts. Thrushes, and more particularly the missel thrush, were noticed as being very scarce in many localities, owing to the number of these birds which had been killed by the severity of the winter of 1890-91. As was the case in the previous year green vegetables were very scarce, owing to the havoc made among them by the keen winter and spring frosts, assisted by the sodden state of the ground in the early part of the year.

The long frost in March greatly retarded the first flowering of both the coltsfoot and wood anemone, the former being about three weeks, and the latter from three weeks to a month later than the adopted mean. Indeed, during this period the departures from the average were greater than at any other time during the year. The blackthorn was only from about a week to a fortnight late, garlic hedge mustard from a few days to a week late, the horse-chestnut from a week to a fortnight late, while the hawthorn, which blossomed profusely in some localities, but sparsely in others, was less than a week behind time in showing its first flower in most districts.

The spring migrants, the swallow, the cuckoo, the nightingale, and the flycatcher made their appearance as a rule, if anything, rather earlier than in 1891. The wasp was first observed a few days later than in the previous year, while the small white and orange tip butterflies put in an appearance from a week to ten days earlier than in 1891.

Observers' Notes.

MARCH.—*St. Davids* (A.). Grass lands very bare. *Aberystwith* (A.). 28th and 29th. Lambs dying by hundreds in the hill country owing to snow of 27th and frost of succeeding nights. Ewes nearly starved and too feeble to give them sufficient nourishment. *Pennington* (C.). All farming operations still very backward owing to wet autumn and winter. No grass at all, spring food for sheep scarce. *Strathfield Turgiss* (C.). All agricultural and vegetable progress retarded by frost. *Beckford* (D.). 1st. No record of so much land intended for autumn wheat

TABLE I.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1892.

District and Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse Chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.	Ivy.
A.													
Penzance (Mara.)	(88)	79	..	100	..	..	140	(175)	165	(195)	..	200	261
Falmouth	40	47	102	82	..	123	133	146	162	167	..	187	259
Liskeard	55	64	100	95	(132)	144	132	..	..	..	..	..	..
Tiverton	39	69	91	97	110	138	134	156	156	158	..	..	284
Bideford (W. Ho)	..	71	..	100	102	..	139	..	165	187	..	..	..
Bideford (Instow)	25	78	84	94	..	..	..	..	..	..	..	..	..
Axbridge (Sidcot)	36	54	78	97	112	131	136	157	163	165	..	..	..
Axbridge (Sidcot)	(7)	66	94	102	114	130	141	149	(152)	..	..	..	289
Bristol (Clifton)	..	..	101	106	..	130	134	156	163	..	..	..	..
Bristol (Clifton)	38	..	..	..	..	..	..	..	..	..	..	..	..
Cardiff	40	(82)	(65)	..	..	135	139	..	..	..	..	..	258
Cardiff (Castle.)	41	56	93	98	112	126	133	145	156	187	..	182	..
Newport (Bassal.)	..	..	..	108	..	.	..	..	163	..	..	207	271
Chepstow (St.Ar.)	..	..	..	..	..	..	..	..	..	..	..	..	255
St. David's	..	..	..	101	..	..	141	..	..	..	..	..	..
Aberystwith	43	72	91	96	104	140	127	138	162	..	184	185	..
B.													
Killarney	28	54	72	75	101	136	126	146	158	181	(202)	191	251
Wicklow	28	67	94	66	113	132	133	140	166	(206)	..	217	267
C.													
Charmouth .... (Whit. Can.)	29	44	84	96	103	127	128	141	162	163	..	169	..
Blandford	24	(82)	85	98	114	139	135	144	162	176	201	205	(316)
Wincanton (B.W.)	32	52	85	100	100	142	134	137	..	..	..	183	..
Lymington (Pen.)	38	55	92	98	122	134	129	142	162	186	172	(218)	270
Winchfield (S. T.)	34	(93)	103	101	112	135	138	143	158	164	..	180	271
Hastings (Bexhill)	(91)	..	91	93	127	127	141	..	(149)	..	..	..	303
Horsham (Mun.)	31	53	76	99	114	133	136	145	162	168	..	..	..
Dover	(99)	..	..	107	..	136	147	..	174	189	..	..	277
Tunbridge Wells	..	43	..	..	..	..	..	..	..	..	..	..	..
Canterbury	37	(84)	96	108	..	141	147	144	171	..	..	..	275
Farnborough ..	36	42	93	(113)	115	136	134	147	..	..	..	..	..
Beckenham	..	..	..	..	113	135	..	(181)	..	..	..	..	..
Ewhurst (Coney.)	37	..	95	101	(131)	133	136	143	158	..	183	195	..
Farnham (Churt)	54	..	94	103	115	..	..	..	163	..	..	..	..
Cranleigh (Wint.)	59	40	87	106	..	134	141	157	156	170	194	(156)	272
Cranleigh (Will.)	..	..	..	..	..	138	135	149	..	..	..	..	..
Leatherhead (O.)	..	..	99	105	124	141	136	149	161	..	..	.	..
Weybridge (Add.)	42	75	96	105	124	138	139	152	163	174	197	191	..
East Molesey ..	38	74	100	100	117	134	134	..	161	171	..	206	..
Salisbury	..	..	79	97	106	142	120	142	..	..	..	..	..
Marlborough ..	29	41	84	99	113	144	141	..	161	167	174	..	256
Reading (Whitc.)	34	..	(107)	100	..	..	136	..	..	..	.	..	..
Henley-on-Tha.	31	(86)	82	91	..	..	..	..	..	..	..	..	..
Reading	..	..	..	..	..	135	136	..	..	..	..	..	..
D.													
Oxford ...	..	..	90	..	117	136	136	152	162	..	..	195	251
Cheltenham	30	65	79	102	120	136	134	160	158	173	199	192	262
Tewkesbury	32	65	89	103	114	134	135	142	156	169	193	180	..
St. Albans	..	..	..	100	115	147	138	140	162	..	197	197	268
Berkhamsted ..	46	73	99	111	116	143	146	149	158	183	192	183	..
Harpenden	31	78	92	104	115	137	143	146	153	168	186	190	..
Ross	(3)	..	..	108	..	..	132	..	..	..	..	..	..
Hereford (Brein.)	35	78	82	101	110	140	143	149	155	172	192	184	254
Evesham	79	78	91	104	114	138	137	..	154	..	186	207	272
Henley-in-Arden	32	69	(62)	95	(140)	135	136	146	162	179	..	..	..
Northampton ..	(83)	(100)	..	113	117	140	142	146	162	180	..	202	258
Churchstoke	43	76	94	106	117	145	144	144	163	(202)	197	204	306
Hinckley	..	..	..	119	..	140	145	..	..	..	..	..	305
Thurcaston	40	..	..	112	116	143	142	149	165	172	..	..	..
Uppingham ..	42	79	86	..	121	..	142	161	158	169	185	..	..
Walsall	45	80	82	101	128	144	146	158	179	183	185	192	274

TABLE I.—Date (Day of Year) of First Flowering of Plants, 1892—*Continued*.

District and Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse Chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
D.													
Burton-on-Trent	45	58	94	..	115	146	146	..	..	..	..	..	..
Stoke (Tean)	80	86	102	..	..	151	148	159	172	..	177	..	..
Beeston	39	80	..	113	..	141	143	161	..	..	..	..	..
Worksop (Hods.)	31	77	97	107	123	136	146	154	165	172	189	188	284
Bakewell	(89)	89	96	123	142	148	150	159	179	191	193	211	..
Macclesfield	78	80	(117)	127	119	154	150	(167)	178	192	195	196	..
Grantham (Belt.)	41	83	99	111	120	143	142	155	158	..	..	..	..
Huddersfield ..	44	83	93	..	142	157	(163)	..	..	..	..	219	..
Harrogate	41	78	98	112	126	146	152	159	176	192	198	221	..
E.													
Hertford	21	40	80	101	106	..	..	..	..	..	203	197	262
Hitchin	..	..	..	..	..	138	136	145	153	190	185	202	274
Braintree	..	..	..	..	129	137	144	153	158	195	..	..	(248)
Colchester (Lex.)	43	..	100	109	..	135	138	..	..	..	..	..	257
Ipswich (Sproug.)	34	..	96	113	..	138	144	154	166	200	..	..	274
Wymondham (T.)	39	..	..	117	..	134	..	..	161	184	..	194	..
Wryde	(92)	83	96	105	..	136	142	..	163	..	..	(165)	..
F.													
Chester	41	75	..	..	..	..	..	..	..	..	..	..	..
Parkgate (Hesw.)	..	51	79	(136)	..	141	140	..	..	..	..	..	..
Caton (Claugh.)	..	92	95	115	..	..	..	157	176	210	194	..	..
Settle	..	..	94	114	130	..	149	158	167	190	..	(227)	..
Settle (Giggles.)	41	57	94	..	(143)	..	147	164	175	192	190	204	302
Ambleside	34	..	100	112	..	..	149	..	169	..	..	..	..
Egremont	44	53	98	102	121	136	136	155	166	175	177	195	291
Orry's Dale	..	86	112	113	..	105	(107)	(108)	167	..	190	188	294
G.													
Edgeworthstown	..	..	..	106	..	136	145	..	..	..	..	..	..
Collon	58	..	..	112	..	141	145	154	178	198	..	..	..
Loughbrickland	(80)	87	96	116	..	149	141	..	172	..	..	..	..
Saintfield	51	..	..	105	..	138	144	152	176	..	..	..	281
Antrim	68	..	80	104	119	142	149	..	..	209	..	(231)	289
Londonderry ..	49	..	..	..	..	..	..	..	..	..	..	..	..
Londonderry ..	42	..	..	94	..	..	..	149	..	..	..	..	..
H.													
Dalry (Dalshan.)	..	92	(125)	120	..	..	..	(179)	181	..	193	..	..
Tynron	43	(121)	121	122	..	..	..	..	..	..	..	..	..
Thornhill	43	80	..	..	..	..	..	..	..	..	..	..	..
Jardington	41	..	98	118	..	148	151	..	171	..	190	..	..
Helensburgh ..	43	91	100	105	132	140	146	164	170	215	(214)	194	289
I.													
Doddington	80	85	93	112	131	140	145	154	168	..	..	180	..
Driffield........	39	43	..	120	..	147	150	..	177	220	..	..	284
Thirsk	36	63	88	101	118	136	136	154	165	(178)	187	216	283
Darlington (E. L.)	..	..	111	123	..	145	150	..	177	..	..	..	..
Durham	43	79	94	124	..	154	150	170	179	211	197	..	314
Gateshead (L. F.)	108	101	122	129	..	152	150	..	184	233	223	..	..
J.													
Aberdeen	..	84	114	..	..	156	154	(186)	(191)	..	224	..	..
K.													
Garve (Inverbr.)	..	78	..	..	..	..	..	..	..	..	..	..	..

The dates in brackets have not been taken into consideration when calculating the means given in Table II.

Explanation of the dates in the Tables.

1– 31 are in	January.	183–213 are in	July.
32– 60 ,,	February.	214–244 ,,	August.
61– 91 ,,	March.	245–274 ,,	September.
92–121 ,,	April.	275–305 ,,	October.
122–152 ,,	May.	306–335 ,,	November.
153–182 ,,	June.	336–366 ,,	December.

TABLE II.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF PLANTS IN 1892, AND THEIR VARIATIONS FROM THE AVERAGE.

Plants.	A. Eng. S.W.			B. Ireland, S.			C. Eng. S.			D. Eng. Mid.		
	1892.	Approximate Average.	Variation from Average.	1892.	Approximate Average.	Variation from Average.	1892.	Approximate Average.	Variation from Average.	1892.	Approximate Average.	Variation from Average.
Hazel	40	23	+17	28	21	+ 7	37	31	+ 6	45	35	+10
Coltsfoot	66	44	+22	61	42	+19	52	52	Av.	77	56	+21
Wood Anemone	93	58	+35	83	56	+27	90	66	+24	92	70	+22
Blackthorn	98	91	+ 7	71	91	−20	100	91	+ 9	109	93	+16
Garlic Hedge Mustard	109	111	− 2	107	111	− 4	115	111	+ 4	120	113	+ 7
Horse Chestnut	133	126	+ 7	134	126	+ 8	136	126	+10	143	128	+15
Hawthorn	136	131	+ 5	130	131	− 1	134	131	+ 3	142	133	+ 9
White Ox Eye	150	139	+11	143	139	+ 4	145	139	+ 6	152	141	+11
Dog Rose	162	156	+ 6	162	160	+ 2	161	155	+ 6	164	158	+ 6
Black Knapweed	173	175	− 2	181	179	+ 2	173	174	− 1	178	177	+ 1
Harebell	184	189	− 5	..	*193*	..	187	188	− 1	191	191	Av.
Greater Bindweed	192	195	− 3	204	199	+ 5	190	194	− 4	191	197	− 6
Ivy	268	263	+ 5	259	266	− 7	275	270	+ 5	273	274	− 1
Mean for the 13 Plants	139	131	+ 8	130	127	+ 3	138	133	+ 5	144	136	+ 8

Plants.	E. Eng. E.			F. Eng. N.W.			G. Ireland, N.			H. Scotland, W.		
	1892.	Approximate Average.	Variation from Average.	1892.	Approximate Average.	Variation from Average.	1892.	Approximate Average.	Variation from Average.	1892.	Approximate Average.	Variation from Average.
Hazel	34	36	− 2	40	32	+ 8	54	29	+25	43	33	+10
Coltsfoot	62	57	+ 5	69	53	+16	87	50	+37	88	54	+34
Wood Anemone	97	71	+26	96	67	+29	88	64	+24	106	68	+38
Blackthorn	109	95	+14	111	97	+14	106	97	+ 9	116	99	+17
Garlic Hedge Mustard	118	115	+ 3	126	117	+ 9	119	117	+ 2	132	119	+13
Horse Chestnut	136	130	+ 6	127	132	− 5	141	132	+ 9	144	134	+10
Hawthorn	141	135	+ 6	144	137	+ 7	145	137	+ 8	149	139	+10
White Ox Eye	151	143	+ 8	159	145	+14	152	145	+ 7	164	147	+17
Dog Rose	160	157	+ 3	170	161	+ 9	175	164	+11	174	164	+10
Black Knapweed	192	176	+16	192	180	+12	204	183	+21	215	183	+32
Harebell	194	190	+ 4	188	194	− 6	..	*197*	..	192	197	− 5
Greater Bindweed	198	196	+ 2	196	200	− 4	..	*203*	..	194	203	− 9
Ivy	267	273	− 6	296	271	+25	285	271	+14	289	273	+16
Mean for the 13 Plants	143	136	+ 7	147	137	+10	141	126	+15	154	139	+15

\+ indicates the number of days later than the average date.
— „ „ „ earlier „ „
Av. „ average date.

N.B.—The dates in Italics have not been taken into consideration when calculating the mean dates at the bottom of the Table, nor the means for the British Isles.

planting being left unsown until now. *Harpenden* (D.). A gardener of some experience tells me the past winter and spring have been the most trying for vegetation he has ever known. *Churchstoke* (D.). Fodder very scarce and pastures very bare. *Hinckley* (D.). 6th. Pied wagtail first seen. *Walsall* (D.). 16th. No sign of vegetable growth since February 15th. *Sproughton* (F.).

TABLE II.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF PLANTS IN 1892, AND THEIR VARIATIONS FROM THE AVERAGE—*Continued.*

Plants.	I. Eng. N.E.			J. Scotland, E.			K. Scotland, N.			British Isles.		
	1892.	Approximate Average.	Variation from Average.	1892.	Approximate Average.	Variation from Average.	1892.	Approximate Average.	Variation from Average.	1892.	Approximate Average.	Variation from Average.
Hazel	50	37	+13	..	*38*	..	..	*37*	..	41	31	+10
Coltsfoot	74	58	+16	84	59	+25	78	58	+20	73	53	+20
Wood Anemone	102	72	+30	114	73	+41	..	*72*	..	96	67	+29
Blackthorn	118	102	+16	..	*103*	..	..	*110*	..	104	95	+ 9
Garlic Hedge Mustard	125	122	+ 3	..	*123*	..	..	*130*	..	119	115	+ 4
Horse Chestnut	146	137	+ 9	156	138	+18	..	*145*	..	140	131	+ 9
Hawthorn	147	142	+ 5	154	143	+11	..	*150*	..	142	136	+ 6
White Ox Eye	159	150	+ 9	..	*151*	..	..	*158*	..	153	143	+10
Dog Rose	175	163	+12	..	*166*	..	..	*173*	..	167	160	+ 7
Black Knapweed	221	182	+39	..	*185*	..	..	*192*	..	192	179	+13
Harebell	202	196	+ 6	224	199	+25	..	*206*	..	195	193	+ 2
Greater Bindweed	198	202	— 4	..	*205*	..	..	*212*	..	195	198	— 3
Ivy	294	274	+20	..	*277*	..	..	*276*	..	278	271	+ 7
Mean for the 13 Plants	155	141	+14	146	122	+24	78	58	+20	146	136	+10

+ indicates the number of days later than the average date.
— " " " earlier " "
Av. " average date.

N.B.—The dates in Italics have not been taken into consideration when calculating the mean dates at the bottom of the Table, nor the means for the British Isles.

The missel thrush appears to have suffered most of the thrush family from the severe winter of 1890-91; and is practically extinct as far as I can see at present. *Wryde* (E.). 10th. Pied wagtail first seen. *Ballynagard* (G.). 1st. Ivy still flowering. *Thornhill* (H.). This month has been favourable for working the land, *Doddington* (I.). First catkins of hazel killed by frost, and the fertile flowers only appeared with the second catkins. *Low Fell* (I.). 16th. Rooks returned to their breeding places. *Inverbroom* (K.). 17th-19th. Rapid rise of temperature with consequent flood owing to melting snow.

APRIL.—*Sidcot* (A.). 9th. Blackthorn in two places "snowed over" with blossom. 12th. Owing to drought and warmth of last week many of the pastures were as bare and as colourless as in January. 25th-27th. Growing rains. *Aberystwith* (A.). Scarcely any rain at all and not a single warm shower. 3rd. Tadpoles hatched. *Buckhorn Weston* (C.). 8th. House martin first seen. *Pennington* (C.). Migratory birds generally late in arriving. *Canterbury* (C.). 7th. All the first catkins on hazel were killed by frost, but fresh catkins have been formed and are now in flower. *Farnborough* (C.). 16th. The growth of plants retarded by a fall of snow one foot deep. *Churt* (C.). Many early shoots of Tea roses destroyed by frost in the middle of the month. *East Molesey* (C.). 12th. Chiff-chaff heard. 30th. Nightingales abundant. *St. Albans* (D.). The cuckoo made its appearance unusually early this year. *Berkhamsted* (D.). 23rd. Wild cherry in blossom 6 days earlier than its mean date of flowering in the previous six years. *Harpenden* (D.). Vegetation upon the whole is late owing to the lowness of temperature, especially during the nights. The bright sunshine during the early days of the month caused wild flowers to expand their blossoms rapidly and extensively; and a large number of the large white cabbage butterflies were seen. *Churchstoke* (D.). Rain much needed. *Tean* (D.). 10th. Chiff chaff first heard. 11th. Willow wren first heard. 23rd. Tree-pipit heard. *Macclesfield* (D.). 2nd. Leaf buds of sycamores, lilacs, and hawthorns only now beginning to swell. *Sproughton* (E.). 30th. Very few

TABLE III.—[illegible]

District.	Station.	[illegible] Song Thrush First heard.	Migrants. Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.
A.	Penzance ([illegible])	..	[illegible]	115	..	..	281
„	Falmouth	..	[illegible]	115		142	..
„	Liskeard	[illegible]	[illegible]	112	..	138	..
„	Bideford (Westward Ho)	[illegible]	[illegible]	118	..	..	..
„	Bideford (Instow)	..	..	[illegible]	..	..	..
„	Axbridge (Sidcot)	24	112	116	..	..	..
„	Axbridge (Sidcot)	..	111	115	117	142	281
„	Bristol (Clifton)	..	114	114	120	..	..
„	Cardiff	40	121	116	..	129	282
„	Cardiff (Castleton)	38	93	[illegible]	..	144	..
„	Newport (Bassaleg)	..	113	117	(141)	..	284
„	Chepstow (St. Arvan's)	..	..	..	..	..	278
„	St. David's	..	120	117	..	..	279
„	Aberystwith	31	101	119	..	135	..
B.	Killarney	23	104	..	..	..	265
„	Wicklow	(57)	110	(125)	..	..	292
C.	Charmouth (Whitchurch Canonicorum)	24	110	112	101	..	..
„	Blandford	(1)	114	99	120	(176)	302
„	Wincanton (Buckhorn Weston)	..	114	98	..	122	..
„	Lymington (Pennington)	34	102	114	123	136	294
„	Winchfield (Strathfield Turgiss)	38	97	108	113	116	275
„	Hastings (Bexhill-on-Sea)	32	115	114	113	141	327
„	Horsham (Mannings Heath)	31	95	110	111	138	304
„	Dover	..	118	..	109	..	334
„	Canterbury	38	109	113	109	(179)	..
„	Sittingbourne (Lynsted)	..	121	114	115	..	..
„	Beckenham	..	..	117	..	..	..
„	Ewhurst (Coneyhurst)	(58)	111	108	106	155	..
„	Farnham (Churt)	..	103	111	112	..	..
„	Cranleigh (Winterfold)	38	100	102	106	125	290
„	Cranleigh (Willinghurst)	..	(129)	101	114	..	..
„	Leatherhead (Oxshott)	..	109	114	121	(162)	..
„	Weybridge (Addlestone)	31	102	113	109	104	..
„	East Molesey	24	99	117	122	..	..
„	Salisbury	..	106	114	..	..	..
„	Marlborough	36	101	107	..	121	310
„	Reading (Whitchurch)	31	..	115	..	..	..
„	Henley-on-Thames	14	107	(122)	..	..	..
D.	Oxford	..	114	114	..	..	..
„	Cheltenham	(59)	105	115	129	145	280
„	Tewkesbury (Beckford)	21	100	115	113	125	284
„	St. Albans	..	..	115	..	..	..
„	St. Albans	36	112	93	108	..	311
„	Berkhamsted	31	89	119	122	(169)	301
„	Harpenden	35	116	111	113	..	..
„	Ross	23	99	117	..	143	..
„	Hereford (Breinton)	31	115	115	..	142	283
„	Evesham	..	102	114	114	..	278
„	Henley-in-Arden	..	112	..	..	..	..
„	Churchstoke	31	116	121	..	137	285
„	Hinckley	..	104	118	..	144	285
„	Thurcaston	..	118	..	..	..	..
„	Uppingham	..	..	117	(133)	142	..
„	Walsall	37	118	119	..	..	..
„	Stoke-on-Trent (Trentham)	30	112	114	..	..	299
„	Ilkeston	31	98	118	..	134	..

TABLE III.—DATE (DAY OF YEAR) OF MIGRATION OF BIRDS, 1892.—*Continued.*

District.	Stations.	Song.	Migration.				
		Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.
D.	Worksop (Hodsock)	37	112	118	121	137	288
„	Retford (Eaton)	30	103	117	116	..	301
„	Bakewell	..	114	117	..	..	279
„	Macclesfield	(77)	(133)	130	..	..	..
„	Grantham (Belton)	30	112	116	114	134	..
„	Huddersfield	44	(128)	128	..	..	..
„	Harrogate	31	106	122	..	122	..
E.	Hitchin	25	116	115	95	..	..
„	Braintree	..	..	113	112	..	..
„	Colchester (Lexden)	24	100	109	111	(171)	288
„	Ipswich (Sproughton)	30	117	117	110	134	303
„	Wryde	(77)	113	118	..	..	..
F.	Parkgate (Heswall)	15	110	120	..	..	..
„	Caton (Claughton)	..	(123)	129	..	..	..
„	Settle (Giggleswick)	38	116	125	..	131	274
„	Ambleside	39	118	119	..	..	..
„	Egremont	29	115	..	116	116	271
„	Douglas	43	116	116	..	(87)	299
„	Orry's Dale	24	..	118	..	..	..
G.	Edgeworthstown	28	103	122	..	132	..
„	Collon	42	113	126	..	(157)	..
„	Loughbrickland	(55)	108	122	..	..	256
„	Saintfield	31	104	125	..	143	273
„	Antrim	39	109	122	..	136	271
„	Londonderry	(58)	..	..	..	..	..
„	Londonderry (Ballynagard)	30	99	133	..	..	..
H.	Dalry (Dalshangan)	..	118	117	..	..	273
„	Tynron	44	(127)	121	..	..	..
„	Jardington	38	118	120	..	..	..
„	Helensburgh	23	119	122	..	..	272
I.	Doddington	..	..	122	..	..	..
„	Driffield	41	121	121	..	..	278
„	Thirsk	31	111	125	..	..	274
„	Darlington (East Layton)	40	120	(137)	..	136	271
„	Durham	29	111	122	..	140	299
„	Gateshead-on-Tyne (Low Fell)	..	129	129	..	..	267
J.	Aberdeen	28	123	135	..	134	(240)
K.	Garve (Inverbroom)	..	..	..	..	..	292
	Mean Dates for the British Isles in 1892	32 Feb. 1st	109 April 18th	116 April 25th	114 April 23rd	134 May 13th	287 Oct. 13th

The dates in brackets have not been taken into consideration when calculating the means for the British Isles.

queen wasps this spring, and remarkably few wasps last autumn. *Giggleswick* (F.). 11th. Willow wren first seen. *Douglas* (F.). 4th. First brown lizard seen. *Collon* (G.). The cold winds have browned the tips of nearly all the trees. *Dalshangan* (H.). 1st. Larch in blossom. 24th. Primrose and celandine in flower. *Low Fell* (J.). 19th. House martin first seen.

MAY.—*Sidcot* (A.). 31st. Owing to drought grass very thin and poor. Seeds and plants in garden only just hold their own but make no progress. *Bassaleg* (A.). The nightingale was heard from Garth Hill, Bassaleg, for the first time for many years. *St Davids* (A.). 8th. Corncrake first heard. *Aberystwith* (A.). 18th. First steady rain which set the grass growing. *Killarney* (B.). Much

TABLE IV.—DATE (DAY OF YEAR) OF FIRST APPEARANCE OF INSECTS, 1892.

District.	Stations.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
A.	Penzance (Marazion)	89	..	94	152	181
,,	Falmouth	..	..	82	142	..
,,	Liskeard	25	100	85	127	..
,,	Bideford (Westward Ho)	56	..	..	103	162
,,	Bideford (Instow)	44	..	..	..	..
,,	Axbridge (Sidcot)	43	103	95	121	..
,,	Axbridge (Sidcot)	..	..	121	116	..
,,	Bristol (Clifton)	..	..	92	136	174
,,	Bristol (Clifton)	78	..	..	..	..
,,	Cardiff (Penarth)	57	(203)	97	..	171
,,	Cardiff	40	96	..	92	..
,,	Cardiff (Castleton)	57	97	121	115	134
,,	Newport (Bassaleg)	..	147	121	..	..
,,	St. David's	76	..	91	128	..
,,	Aberystwith	55	100	98	129	173
B.	Killarney	57	101	91	127	129
,,	Wicklow	41	94	91	130	129
C.	Charmouth (Whitchurch Canonicorum)	24	104	96	..	..
,,	Blandford	81	135	81	102	(195)
,,	Wincanton (Buckhorn Weston)	24	100	99	100	..
,,	Lymington (Pennington)	36	98	91	130	174
,,	Winchfield (Strathfield Turgiss)	24	101	113	102	137
,,	Hastings (Bexhill-on-Sea)	93	141	96	149	154
,,	Horsham (Muntham)	25	138	115	132	..
,,	Canterbury	78	122	99	..	..
,,	Ewhurst (Coneyhurst)	77	99	112	..	..
,,	Farnham (Churt)	57	..	..	141	..
,,	Cranleigh (Winterfold)	56	115	..	..	..
,,	Cranleigh (Willinghurst)	..	128	..	..	..
,,	Weybridge (Addlestone)	59	77	..	..	..
,,	East Molesey	56	100	98	130	..
,,	Salisbury	80	..	93	..	..
,,	Marlborough	55	92	98	121	169
,,	Henley-on-Thames	76	42	96	..	..
D.	Oxford	93	..	99	..	..
,,	Cheltenham	55	97	98	95	172
,,	Tewkesbury (Beckford)	24	134	115	142	158
,,	St. Albans	41	..	..	144	..
,,	Berkhamsted	78	79	93	142	..
,,	Harpenden	30	113	99	134	..
,,	Ross	52	101	..	..	..
,,	Hereford (Breinton)	78	99	94	100	182
,,	Evesham	78	97	101	144	156
,,	Henley-in-Arden	86	78	95	..	..
,,	Northampton	79	..	121	..	180
,,	Churchstoke	89	108	115	114	185
,,	Hinckley	76	78	101	147	..
,,	Thurcaston	..	141	..	149	..
,,	Uppingham	78	74	79	147	159
,,	Walsall	78	80	127	..	..
,,	Stoke-on-Trent (Tean)	78	..	..	..	..
,,	Beeston	50	132	94	..	..
,,	Worksop (Hodsock)	41	92	100	148	..
,,	Bakewell	..	114	126	..	..
,,	Macclesfield	..	..	121	..	..
,,	Grantham (Belton)	38	94	..	145	..
,,	Huddersfield	(118)	..	119	..	..

TABLE IV.—DATE (DAY OF YEAR) OF FIRST APPEARANCE OF INSECTS, 1892—*Continued.*

District.	Stations.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
D.	Harrogate	91	125	101	..	150
E.	Hitchin	..	151	..	..	..
"	Colchester (Lexden)	77	113	101	131	..
"	Ipswich (Sproughton)	56	121	113	145	..
"	Wymondham (Tacolneston)	24	..	..	..	..
"	Wryde	76	..	97	155	..
F.	Parkgate (Heswall)	(112)	63	..	..	..
"	Caton (Claughton)	..	123	..	..	..
"	Settle (Giggleswick)	42	38	..	..	..
"	Ambleside	31	77	..	95	..
"	Egremont	31	100	92	132	194
"	Douglas	81	130	94	..	..
"	Orry's Dale	23	..	..	..	..
G.	Edgeworthstown	(116)	126	..	125	142
"	Collon	78	..	113	113	123
"	Loughbrickland	72	91	98	109	180
"	Saintfield	..	102	116	123	180
"	Antrim	99	85	102	160	..
"	Londonderry (Ballynagard)	..	112	117	123	..
H.	Tynron	89	..	..	..	..
"	Thornhill	79	..	..	..	..
"	Jardington	..	101	122	..	182
"	Helensburgh	80	98	101	..	..
I.	Driffield	42	..	..	..	..
"	Thirsk	31	94	94	133	153
"	Darlington (East Layton)	38	121	98	148	..
"	Durham	84	91	115	152	..
"	Gateshead-on-Tyne (Low Fell)	(122)	94	..	..	..
J.	Aberdeen	85	142	123	..	..
	Mean dates for the British Isles in 1892	60 Feb. 29th	104 April 13th	103 April 12th	129 May 8th	162 June 10th

The dates in brackets have not been taken into consideration when calculating the mean dates for the British Isles.

blight on gooseberry, plum, cherry, &c. on account of bitter winds. *Buckhorn Weston* (C.). 19th. Nothing growing owing to want of rain. No food for the cattle. *Pennington* (C.). Everything very backward and dried up until showers at end of month. Hawthorn blossom abundant. Butterflies numerous and some "clouded yellows" among them. *Churt* (C.). 22nd. Very early appearance of the May fly. *Leatherhead* (C.). 25th. All garden-produce at a standstill until now for want of rain. *Addlestone* (C.). A cold dry spring. 30th. Grass very short, but all farming operations well advanced. *Henley-on-Thames* (C). 8th. Swift first seen. *Oxford* (D). 31st. The drought has considerably retarded the growth of plants generally. *Cheltenham* (D.). A severe winter followed by a very dry spring has severely tried all vegetation. Many garden herbs and all kinds of cabbage have been killed in great quantities. *Beckford* (D.). 1st. Fruit blossom injured by severe frost. *Berkhamsted* (D.). 19th. Only a month since the gorse on Berkhamsted Common never looked so strong or promising for abundant blossom, but now more than one third of the shoots are dead and there is but a scanty show of flowers. *Ross* (D.). 5th. Corncrake first heard. *Churchstoke* (D.). Crops vastly improved and grass in full growth at end of month. *Hinckley* (D.). Neither swallows nor swifts appeared in any number until 12th, when they seemed to come all at once.

TABLE V.—ESTIMATED YIELD OF FARM CROPS IN 1892.

Description of Crop.	England.					
	A. SW.	C. S.	D. Mid.	E. E.	F. NW.	I. NE.
Wheat	11 % O. Av.	12 % U. Av.	4 % U. Av.	18 % U. Av.	12 % O. Av.	6 % O. Av.
Barley	9 % O. Av.	2 % U. Av.	3 % O. Av.	1 % O. Av.	6 % O. Av.	1 % O. Av.
Oats	10 % O. Av.	3 % U. Av.	Av.	6 % U. Av.	2 % U. Av.	3 % U. Av.
Corn Harvest began, average Date	226 (Aug. 13)	222 (Aug. 9)	232 (Aug. 19)	228 (Aug. 15)	242 (Aug. 29)	244 (Aug. 31)
Beans	U. Av.	U. Av.	U. Av.	U. Av.	Av.	U. Av.
Peas	..	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.
Potatoes	Av.	Av.	O. Av.	O. Av.	O. Av.	Av.
Turnips	U. Av.	U. Av.	Av.	U. Av.	U. Av.	U. Av.
Mangolds	U. Av.	U. Av.	U. Av.	Av.	Av.	U. Av.
Hay	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	U. Av.	U. Av.

Description of Crop.	Scotland.			Ireland.	British Isles.
	H. W.	J. E.	K. N.	B. and G. S & N.	
Wheat	6 % O. Av.	Av.	23 % O. Av.	O. Av.	U. Av.
Barley	3 % O. Av.	3 % O. Av.	10 % O. Av.	O. Av.	O. Av.
Oats	3 % O. Av.	Av.	..	O. Av.	U. Av.
Corn Harvest began, average Date	252 (Sep. 8)	254 (Sep. 10)	261 (Sep. 17)	244 (Aug. 31)	241 (Aug. 28)
Beans	Av.	Av.	..	Av.	U. Av.
Peas	..	..	..	..	U. Av.
Potatoes	U. Av.	Av.	Av.	Av.	Av.
Turnips	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.
Mangolds	U. Av.	..	..	Av.	U. Av.
Hay	Av.	U. Av.	U. Av.	U. Av.	U. Av.

Symbols:—O. = Over. U. = Under. Av. = Average.

The variations from the average relating to Wheat, Barley and Oats have been obtained from the *Agricultural Produce Statistics* issued by the Board of Agriculture, but those for the other crops from Returns which appeared in the *Agricultural Gazette*.

Owing to cold and drought followed by growing weather the grasses seemed to run into flower without making much herbage. *Tean* (D.). 2nd. Corncrake first heard. *Beeston* (D.). 20th. Oak very much before the ash this season. *Hodsock* (D.). 30th. Vegetation has made most rapid growth during the last ten days. *Macclesfield* (D.). 25th. I never saw trees so bare at this time of year. *Huddersfield* (D.). 14th. Wild flowers very scarce. *Wryde* (E.). Soil too dry and cold this spring for seed to germinate and for plants to grow, until after the warm rains of this month, when everything seemed to make tremendous growth. 11th. Oak in leaf, but ash not until 17 days later. *Claughton* (F.). The growth of vegetation during latter half of month amazing, owing to showery weather following a long drought. *Giggleswick* (F.). Frost of last month did much damage to evergreens. 6th. Swift first seen; an early date. 14th. A flock of fieldfares seen. *Douglas* (F.). 14th. Sulphur moth first seen. *Antrim* (G.). 12th. After this date owing to much warm rain vegetation has made more rapid and luxuriant growth than I ever remember to have seen before. *Ballymagard* (G.). An unusually dry time for seed sowing this spring. *Dalshangan* (H.). 6th. Dog violet in flower. *Tynron* (H.). At the beginning of the month stock farmers were at their wit's end—importing Dutch and English hay; while the ravages of the field vole were unprecedented. *Driffield* (I.). Berberis Darwinii, which escaped injury in the previous winter, is much

TABLE VI.—ESTIMATED YIELD OF FRUIT CROPS IN 1892.

Description of Crop.	England.					
	A. SW.	C. S.	D. Mid.	E. E.	F. NW.	I. NE.
Apples	U. Av.	Av.	U. Av.	U. Av.	U. Av.	U. Av.
Pears	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.
Plums	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.
Raspberries	Av.	Av.	Av.	O. Av.	U. Av.	O. Av.
Currants	Av.	Av.	Av.	O. Av.	U. Av.	O. Av.
Gooseberries	Av.	Av.	Av.	O. Av.	U. Av.	O. Av.
Strawberries	Av.	Av.	Av.	Av.	Av.	Av.

Description of Crop.	Scotland. H. W. / J. E. / K. N.	Ireland. B. and G. S & N.	British Isles.
Apples	U. Av.	U. Av.	U. Av.
Pears	U. Av.	U. Av.	U. Av.
Plums	U. Av.	U. Av.	U. Av.
Raspberries	Av.	Av.	Av.
Currants	Av.	Av.	Av.
Gooseberries	Av.	Av.	Av.
Strawberries	Av.	U. Av.	Av.

Symbols:—O. = Over. U. = Under. Av. = Average.

This Table has been compiled from Returns which appeared in the *Gardeners' Chronicle.*

damaged by frost. 29th. A succession of grand rains during the past week with warm weather. Vegetation has made an abundant growth, grass and clovers being especially fine. *East Layton* (I.). 13th. Rain much needed. *Durham* (I.). 5th. First swift seen. 31st. Swifts and swallows seem more plentiful than last year. *Low Fell* (I.). 23rd. Swift first seen. *Aberdeen* (J.). 14th. The first good rain for some weeks has caused vegetation to make great progress.

The Summer.

All the three summer months proved more or less cold. The variations from the average were not, however, great in either June or August, whereas in July the mean temperature of the month fell short of that which may be regarded as seasonable by as much as from 1°·3 in the south-west of England to 4°·3 in the north-eastern and northern counties. The early part of June was warm and sunny with occasional heavy showers, but in the second week a change to cold, dull and dry weather took place. During this cold spell, which lasted about a week, the day temperatures remained very low, while most of the nights were as unseasonably cold and on the 15th there occurred in many localities a ground frost.

At the beginning of June vegetation made rapid strides, and the corn and other crops presented a greatly improved appearance. Unfortunately the warm rains came too late to be of much service to the hay, which in all but the north of England and in Scotland and Ireland was but a very scanty crop, although in most districts harvested in splendid condition. During the term of cold and gloomy weather which followed very little growth indeed was

TABLE VII.

APPROXIMATE VARIATIONS FROM THE AVERAGE IN MEAN TEMPERATURE, RAINFALL, AND SUNSHINE, 1891–92.

Winter 1891–92.

Temperature.

Months.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
December	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	+1·6	+1·8	−0·4	+0·2	+1·4
January	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	−2·8	−3·0	−2·5	−2·5	−2·3	−2·8
February	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	−1·0	−0·5	−1·5	−2·0	−1·8	−2·0
Winter	[illegible]	[illegible]	[illegible]	[illegible]	−1·2	−0·9	−0·6	−0·7	−1·6	−1·3	−1·1

Rain.

Months.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
December ..	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	+2·4	+1·1	+2·7	−0·2	+0·5	+0·9
January ..	[illegible]	[illegible]	−1·7	[illegible]	−0·8	−0·1	−0·3	−1·0	−0·4	−0·3	+0·1
February	[illegible]	[illegible]	−0·7	[illegible]	−0·1	−0·2	−0·5	−2·0	+0·1	−0·3	−1·3
Winter	[illegible]	−1·3	[illegible]	[illegible]	−0·4	+2·5	+0·3	−0·3	−0·5	−0·1	−0·3

Sunshine.

Months.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
December	+ 6	+14	+28	+13	+17	+11	+12	+ 7	0·0	−11	−7
January	+15	− 4	+12	+ [illegible]	− 2	+ 1	− 3	+ 5	+ 1	−11	0
February	+ 5	−11	+ 2	+ 2	− 2	+ 5	− [illegible]	+ 6	+15	− 3	+6
Winter	+25	− 1	+42	+28	+13	+17	+ 2	+18	+16	− 3	−1

Spring 1892.

Temperature.

Months.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
March	−3·4	−4·4	−4·2	−4·2	−4·0	−3·6	−3·0	−3·4	−3·2	−2·8	−2·8
April	[illegible]	[illegible]	−1·0	−1·5	−1·3	−1·0	−1·0	−1·0	−1·8	−1·8	−2·3
May	+0·3	+0·8	[illegible]	+1·0	+1·2	+0·5	0·0	+0·3	+0·5	+0·5	−0·8
Spring ..	−1·1	−1·4	−1·6	−1·6	−1·6	−1·4	−1·3	−1·4	−1·5	−1·4	−2·0

Rain.

Months.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
March	−2·1	−2·1	−0·9	−1·4	−0·4	−1·5	−1·9	−3·3	−0·9	−1·3	−2·4
April	+0·7	−1·3	−0·8	−0·8	0·0	−0·4	−1·0	−1·2	−0·5	−1·1	−0·3
May	−0·8	+0·9	−1·2	−0·2	−0·3	+1·3	+1·8	+2·1	+0·7	+0·5	+0·9
Spring	−2·2	−2·5	−2·9	−2·4	−0·7	−0·6	−1·1	−2·4	−0·7	−1·9	−1·8

Sunshine.

Months.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
March	+ 50	+21	+ 30	+22	+ 2	+ 60	+29	+40	+37	+25	+33
April	+ 58	+54	+ 76	+68	+56	+ 65	+46	+47	+54	+51	+24
May	− 7	−21	+ 18	+ 1	−12	− 22	−24	−11	−13	+ 4	− 5
Spring ...	+101	+54	+124	+91	+46	+103	+51	+76	+78	+80	+52

+ indicates above the average, — below it.

TABLE VII.

Variations from the Average—*Continued.*

Summer 1892.

Temperature.

Months.	Eng. SW.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. NW.	Ire. N.	Scot. W.	Eng. NE.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
June	−1·0	−1·0	−1·0	−0·8	−0·6	−0·6	−0·6	−1·6	−0·6	−1·2	−1·6
July	−1·3	−1·5	−2·5	−3·8	−3·3	−2·8	−2·0	−2·0	−4·3	−3·0	−2·0
August	+0·2	+0·2	0·0	−0·6	−0·8	−0·8	−0·8	−0·8	−0·8	−0·8	−1·0
Summer ..	−0·7	−0·8	−1·2	−1·7	−1·6	−1·4	−1·1	−1·5	−1·9	−1·7	−1·5

Rain.

	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
June	−1·2	+0·6	−0·1	+0·3	+0·5	+0·9	+1·7	+0·6	+1·6	+0·5	+0·3
July	−0·5	−0·1	+0·1	0·0	+0·1	−0·7	−1·1	−0·9	−0·9	−0·9	−0·7
August	+0·2	+3·2	+1·3	−0·2	+0·9	−2·3	+2·3	+3·2	+0·5	+0·8	+1·5
Summer ..	−1·5	+3·7	+1·3	+0·1	+1·5	−2·1	+2·9	+2·9	+1·2	+0·4	+1·1

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
June	+ 1	+ 9	+50	+39	+30	+19	+25	+1	+10	−17	−20
July	+16	0	+13	−33	−34	−27	+ 5	+2	−35	−26	+ 5
August	−20	−48	+ 5	+ 2	+15	+ 2	−11	+1	−16	−10	−18
Summer ..	− 3	−39	+68	+ 8	+11	− 6	+19	+4	−41	−53	−33

Autumn 1892.

Temperature.

	°	°	°	°	°	°	°	°	°	°	
September ..	−1·3	−1·5	−0·8	−1·3	−1·0	−1·3	−1·3	−1·8	−1·0	−2·3	−2·3
October	−4·5	−5·0	−3·8	−4·0	−3·8	−3·5	−3·8	−2·8	−3·8	−3·5	−3·8
November	+1·6	+1·2	+2·0	+0·8	+1·4	+0·6	+1·4	+0·8	0·0	0·0	+1·2
Autumn ..	−1·4	−1·8	−0·9	−1·5	−1·1	−1·4	−1·2	−1·3	−1·6	−1·9	−1·6

Rain.

	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
September ..	−0·4	+0·2	−0·2	−0·5	−0·3	+0·5	+0·4	+0·7	−0·7	−0·8	+2·0
October	−0·2	−0·6	+0·7	+0·3	+2·6	+1·3	−0·1	+0·2	+2·4	+1·2	+0·2
November ...	−1·0	+2·3	+0·9	−0·9	0·0	−1·0	+0·7	−0·8	−1·8	−1·4	+0·2
Autumn ..	−1·6	+1·9	+1·4	−1·1	+2·3	+0·8	+1·0	+0·1	−0·1	−1·0	+2·4

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
September....	−32	−15	− 6	−13	−10	−17	− 1	− 3	+ 8	− 3	−30
October	+23	+20	+10	+13	−12	+14	+11	+12	− 7	−19	−18
November	+ 3	+10	−11	− 4	−26	+ 5	+ 9	+ 2	−13	− 6	− 9
Autumn....	− 6	+15	− 7	− 4	−48	+ 2	+19	+11	−12	−28	−57

The above Table has been compiled from the variations from the mean given in the *Weekly Weather Reports* issued by the Meteorological Office.

made, while potatoes, scarlet runners and other tender vegetables were more or less seriously injured by the remarkably cold night preceding June 15th. Indeed, there appears to have been scarcely any district which entirely escaped this frost. From this time until quite the end of the season there occurred no warm summer weather worth mentioning. Bush fruits and strawberries were as a rule good and fairly plentiful. During August butterflies were exceptionally numerous, and more particularly peacocks, red admirals, and painted ladies. The most noteworthy feature, however, as regards butterflies was the appearance in unusual numbers of the clouded yellow, which was observed in nearly every county in England and Wales as well as in parts of Scotland. Previous to this there had not been a good "clouded yellow year" for fifteen years. The blossom on the hawthorn and wild roses was noticed in many localities as being singularly abundant.

The white ox eye flowered from a week to a fortnight later than the average dates, but the dog rose in most parts of England was only from a few days to a week late in opening its first blossoms, while the harebell and greater bindweed flowered, if anything, in advance of their respective means in many districts. The black knapweed came into flower at about its average date in the southern and midland counties, but, if we may judge from the small number of returns sent in, was remarkably late in the colder parts of our Islands.

The meadow brown butterfly was first noticed about a week earlier than in 1891.

Observers' Notes.

JUNE.—*Falmouth* (A.). 6th. Found a ripe wild strawberry. *St. Davids* (A.). 28th. Cuckoo last heard. *Killarney* (B.). Vegetation splendid. Snails extremely numerous. *Wicklow* (B.). The blossom on the hawthorn and wild roses unusually abundant. A plague of woodlice and the small house moth that attacks woollen goods. *Pennington* (C.). 11th. Began hay harvest. 20th. Hay harvest finished. 30th. Cuckoo last heard. *Churt* (C.). 15th. Nasturtiums killed by frost and in lower part of valley potatoes destroyed as completely as by an April frost. *Addlestone* (C.). 15th. Potatoes injured by frost. *East Molesey* (C.). Orange tip butterflies very common this year. 15th. Potatoes, broad beans and bracken cut by frost. *Whitchurch* (C.). 15th. Potatoes and kidney beans were cut to the ground by frost, the foliage of many oak trees was also injured and turned autumn-brown. *Cheltenham* (D.). Drought and cold have had a very disastrous effect on the pastures. Vegetables very scarce. 15th. Potatoes damaged by frost. *Beckford* (D.). 1st. Meadows very bare. 15th. Potatoes much blackened by frost. *Berkhamsted* (D.). 15th. A few dahlias blackened by frost, but potatoes untouched. In a row of scarlet runners about 6 ins. high growing in an allotment ground near here only those plants were injured which were beyond the pea-sticks with which they had been staked. 29th. Rhubarb leaves riddled by hail and most other foliage more or less injured. *Harpenden* (D.). 8th. First ear of wheat seen out of sheath. 15th. Potatoes greatly damaged by frost, especially in the valleys. *Breinton* (D.). 15th. Potatoes blackened by frost in exposed and damp situations. *Churchstoke* (D.). 14th-20th. Sharp ground frosts did much damage to potatoes, &c. *Hinckley* (D.). 13th. Potatoes blackened by frost in low lying places, gooseberry blossom also injured. *Walsall* (D.). 24th. First hay cut. 27th. Hedges brown, leaves falling off hawthorn, some bushes nearly stripped owing to drought. *Macclesfield* (D.). 13th and 18th. Low growing vegetation checked by frost. *Hitchin* (E.). 15th. Scarlet runners and French beans shrivelled up by frost. Potatoes much damaged on low lying ground. *Lexden*

(E.). 23rd. Hay harvest commenced. *Sproughton* (E.). 15th. Runner beans cut by frost, but potatoes unhurt. *Tacolneston* (E.). 15th. Potatoes cut by frost in exposed situations. *Wrgde* (E.). 15th. Potatoes and kidney beans in places much injured by frost. *Egremont* (F.). Butterflies, with the exception of white ones, rather scarce. 2nd. Hawthorn blossom very abundant, the hedgerows being one mass of white. *Orry's Dale* (F.). 15th. Saw several red admiral butterflies, which are not generally seen here till the end of August. *Helensburgh* (H.). 14th. Gooseberry bushes and lime trees much injured by caterpillars. *Driffield* (I.). 1st. Trees and all vegetation never looked more promising than at the present date. *Thirsk* (I.). 6th-17th. Grass has grown unusually fast. *East Layton* (I.). 17th. Hailstones seriously injured turnip and potato crops.

JULY.—*Sidcot* (A.). 5th. Strawberries and currants especially fine and plentiful. *St. Davids* (A.). Curlews unusually numerous. *Cheltenham* (D.). Beans and peas made slow progress owing to cold weather. *Breinton* (D.). 3rd. Glow worm first seen. *Churchstoke* (D.). Pastures and meadows very dry and hard, rain much needed. *Hodsock* (D.). Gooseberries very scarce owing to severe frost. *Bakewell* (D.) 1st. Hay making began. *Egremont* (F.). 3rd. The white ox eye very abundant, some meadows being perfectly white to the distant observer. *Helensburgh* (H.). 1st. Great want of flavour in bush fruits.

AUGUST.—*St. Davids* (A.). 15th. Corn harvest commenced. *Pennington* (C.). 8th. Began cutting wheat. 25th. Wheat and oats all harvested. *Strathfield Turgiss* (C.). Butterflies have been this summer remarkably numerous, but moths have been somewhat scarce, the cold night temperatures may account for this. Dandelions, purple loosestrife and willow herb extraordinarily abundant and fine. Horse-chestnuts, laburnums, and lilacs very deficient in blossom. *Oxshott* (C.). Soil very dry until end of month and vegetables made very poor growth. 20th. Swift last seen. *Oxford* (D.). Nearly every plant suffered around Oxford through the dryness of the spring and summer; fortunately it was not warm or sunny, or nearly everything would have been parched. *Cheltenham* (D.). Plants drooped very much at times for want of bottom moisture. *Churchstoke* (D.). Pastures bare and poor aftermath, *Hodsock* (D.). Peaches and apricots a good crop but ripening late. Beautiful harvest weather up to the 28th. *Macclesfield* (D.). Very few aphides have been seen this summer. *Lexden* (E.). 8th. Corn harvest began. *Sproughton* (E.). A great year for butterflies—a "clouded yellow" year. The pale variety more abundant this year than on any previous occasion that I have noted. Red admirals, peacocks, and painted ladies in greater numbers than usual. *Tacolneston* (E.). "Clouded yellow" butterflies numerous. *Claughton* (F.). 29th. A great deal of after-math spoilt by floods. *Edgeworthstown* (G.). Total rainfall 7·61 ins. *Driffield* (I.). The crab and sloe have failed to set any fruit. *Durham* (I.). 7th. Last swift seen.

The Autumn.

This like the other three quarters of the phenological year under review was cold. It also proved wet in most districts, and there was a deficiency of bright sunshine. The harvest month of September was, however, only moderately cold, but not so October, the mean temperature of which was considerably below the average in all districts—the departures from the mean ranging from $-2°·8$ in the west of Scotland to as much as $-5°·0$ in the south of Ireland. The last month of the season, on the other hand, proved rather a warm autumn month.

During the principal part of September the weather remained favourable for the ingathering of the corn, but in the more backward districts harvest operations were carried out under the most trying conditions, the crops being very backward, while rain fell heavily and at frequent intervals. Even as late as the end of November a good deal of corn was still to be seen in the

fields in the north of England and also in Scotland. This was all the more unfortunate as it was in these backward districts that the corn crops promised to be the heaviest. One of the most noteworthy features after the middle of the autumn was the saturated condition of the ground owing to the excessive rains in October. The preparation of the land for autumn wheat

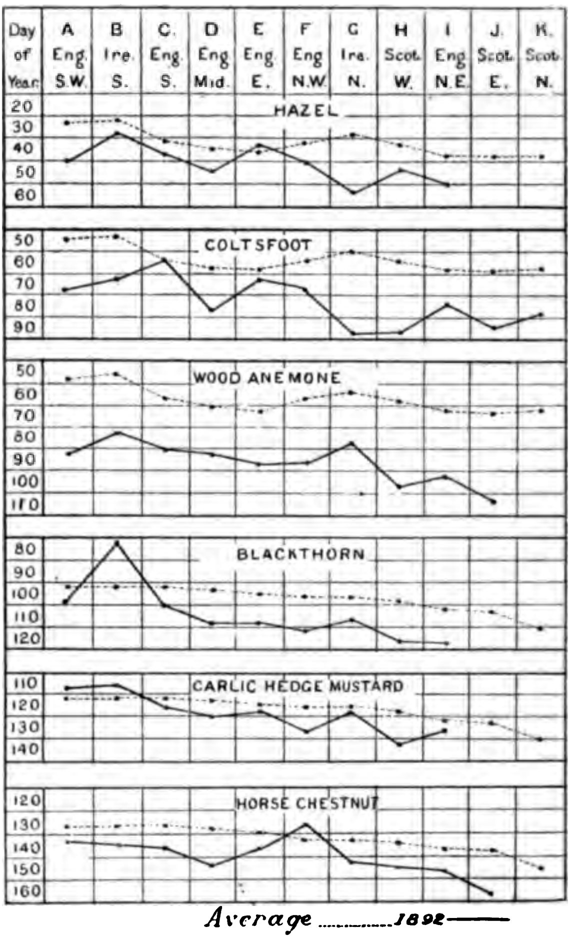

FIG. 1.—Mean Dates (Days of Year) of Flowering of the Plants in 1892, and their variations from the average.

planting was consequently greatly delayed. In some parts of England dahlias were either killed outright or much blackened by frost on October 11th, but in most places their destruction did not take place until October 25th, while in others they lasted well into November. At Salisbury all the dahlias were destroyed by frost as early as September 18th. The autumn tints were fine, and owing to the absence of keen frost lasted longer than usual.

The wheat crop was a very light one, owing in part to the attacks of blight ught on in many places by the June frost. Oats, beans, and peas were much under average. On the other hand, barley yielded well and ved the corn crop of the year. The yield of potatoes where they escaped ase was good, but turnips and mangolds were below average.

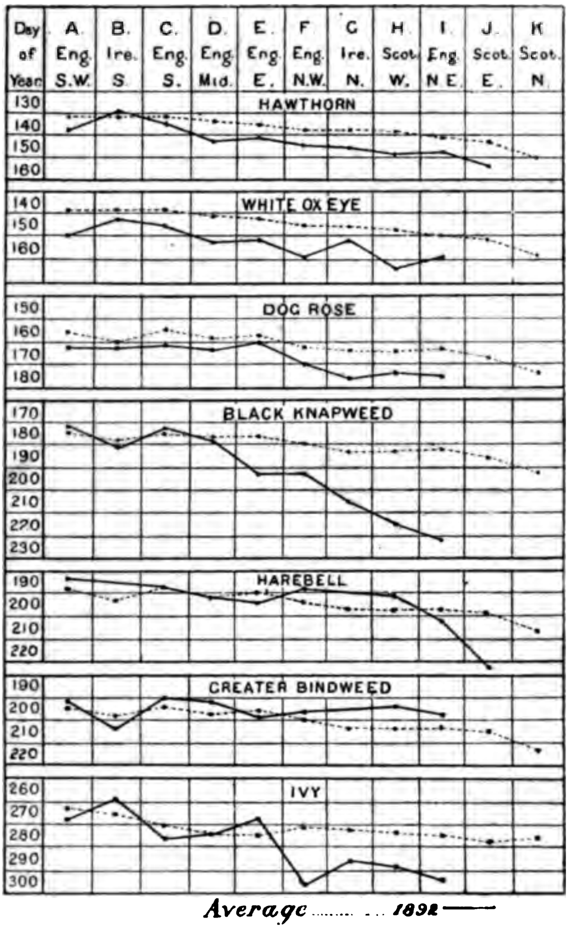

FIG. 2.—Mean Dates (Days of Year) of Flowering of the Plants in 1892, and their lations rom the average.

Plums and pears were almost everywhere a failure, while the crop of les was considerably under the average. No doubt the late spring frosts re in a great measure answerable for the poorness of these crops, but ch must also be attributed to the cold wet weather of the previous autumn venting the fruiting shoots from becoming properly matured.

Ivy came into flower about a week later than the adopted means in the

south and midland counties of England, but was a fortnight or more late in the northern districts.

The last swallows appear to have left most districts a few days earlier than in 1891.

Observers' Notes.

SEPTEMBER.—*St. Arvans* (A.). 18th. An unusual number of butterflies in the garden, painted lady, peacock, red admiral, &c. 28th. Harvest finished. *Wicklow* (B.). 22nd. Leaves beginning to fall from trees. *Pennington* (C.). Potatoes nearly demolished by caterpillars. *Addlestone* (C.). Disastrous frosts about the 18th, which cut down green crops terribly. *Orford* (D.). Great profusion of blossom on the ivy. *Beckford* (D.). Favourable harvest weather till the 19th, corn crops all secured a month earlier than last year. *Evesham* (D.). 29th. The last day on which I saw swallows in large numbers, but many were to be seen six days later at Fladbury, four miles lower down the Avon. *Northampton* (D.). An odd swift or two seen on the 18th, but the main body of them left here about August 29th. *Churchstoke* (D.). A favourable harvest month except for hill farms. *Sproughton* (E.). 18th. Vegetable marrows killed by frost. *Claughton* (F.). 2nd. During the night and early morning occurred the biggest flood known here for 65 years. It is supposed that there must have been a waterspout burst on the hills. *Douglas* (F.). 15th. Swifts last seen. *Antrim* (G.). 21st. Chiff-chaff last seen. *Driffield* (I.). 1st. Corn harvest began. *East Layton* (I.). Much corn still uncut at end of month and very little carried. *Durham* (I.). Snipe are more numerous than during the last two or three years. A small flock of white duck was seen on the river towards the end of the month.

OCTOBER.—*Falmouth* (A.). 31st. Dog rose again in flower. *Sidcot* (A.). 26th. All dahlias killed by frost. *St. Arvans* (A.). 13th. House martins last seen. *Killarney* (B.). Box snails very numerous. Not so many wasps as usual. Scarcely any horse-chestnuts. Mountain ash and holly berries also scarce, but beech nuts very abundant. *Pennington* (C.). At the end of the month, ash, lime, walnut and plane had shed nearly all their leaves, but autumn tints on other trees still in full beauty. 18th. Golden plover first seen. 24th. Dahlias killed by frost. *Addlestone* (C.). The crops of potatoes, turnips, mangolds, apples, &c. secured with difficulty owing to the wet and cold generally prevailing. Ploughing much in arrear. *Marlborough* (C.). Almost all the swallows left on or before October 7th, but a few were seen daily until November 5th. *Cheltenham* (D.). The foliage remained thick on the trees till the end of the third week. 6th. Swallows left remarkably early. *Beckford* (D.). 17th. Martins last seen. *St. Albans* (D.). 29th. Both house martins and swallows were seen flying round and resting on the cathedral. *Berkhamsted* (D.). 26th. Dahlias killed by frost. *Hinckley* (D.). The autumnal tints have been splendid this year. Only a very few swallows remaining after this date. *Tean* (D.). 9th. Most of the swallows left on this day. *Hodsock* (D.). At end of month elms, sycamore and poplars bare. 19th. Dahlias killed by frost. *Hitchin* (E.). Caterpillars of white butterflies inflicted great injury on Brussels sprouts and savoys. *Sproughton* (E.). Song thrush recommenced singing. 25th. Dahlias killed by frost. *Claughton* (F.). 10th. The first frost of the autumn which nipped the dahlias and other tender plants. *Egremont* (F.). 25th-26th. The leaves of trees, owing to frost, have fallen very fast each morning as the sun rose. *Saintfield* (G.). 14th. Much corn still remains out in the fields, while a few fields of oats have not yet been cut. *Antrim* (G.). 7th. House martin last seen 24th and 25th. Autumn tints ruined by intense frosts. Dahlias killed. *Driffield* (I.). 13th-15th. An extraordinary rainfall of 3·55 ins. in three days, doing an immense amount of damage to corn crops still unharvested; in some cases the floods washed the stooks of corn into the drains; newly sown corn also much damaged by the flood. *Thirsk* (I.). 18th and 19th. Severe frosts have stripped off the leaves from the trees, previous to this the autumn tints had been exceptionally beautiful. *Durham* (I.). 25th. Dahlias killed by frost. 31st. Some corn still uncut and a great deal not yet carried. *Inverbroom* (K.). Swallows are rarely seen here.

NOVEMBER.—*Marazion* (A.). 30th. Two house martins seen. *St. Arvans*

(A.). 13th. Fieldfares seen. 29th. Roses and mignonettes still blossoming. *Pennington* (C.). Autumn tints grand during first week, but after this the trees speedily lost their leaves. 8th. Fieldfares first seen. *Strathfield Turgiss* (C.). We have had a wonderful crop of acorns and of the "haws" of hawthorn. The bushes are now quite red with fruit. The "hips" of the dog rose are also extremely abundant. *Addlestone* (C.). Farm work progressed with difficulty owing to the saturated condition of the soil. *Whitchurch* (C.). The leaves have all fallen very rapidly, especially those of the elms, which seldom shed their foliage here entirely until the end of the month, whereas this year they were bare on the 10th. *Northampton* (D). Owing to the absence of severe frost the foliage was lost from the trees very gradually. *Hitchin* (E.). 23rd. Fieldfares heard and seen. *Helensburgh* (H.). The leaves of trees did not show signs of falling until the beginning of the month *Driffield* (I.). 30th. Some corn still out in the fields on the high wolds. This has been the most backward harvest of the past quarter of a century. *Thirsk* (I.). 14th. A great deal of corn is still out and a good deal still to cut. *Aberdeen* (J.). The grain crops were not all secured at the end of the month. Owing to persistent rains since September the grain is very light and inferior in quality, while the very heavy crop of straw is rendered almost worthless.

The Year 1892.

The phenological year ending November 1892 proved on the whole very cold and backward. During the first five months the frequent frost and dry weather greatly retarded vegetation. Consequently all the early wild flowers were very late in coming into blossom. On the arrival, however, of warm rains in the latter part of May rapid progress was for a time made, and the departures from the average in the flowering of trees, shrubs and plants became gradually less marked. In fact, in the early part of July their dates of blossoming were about seasonable. But after this the coldness of the rest of the summer and also of the autumn months caused plants to be again backward in coming into bloom, particularly in the northern districts of our island.

DISCUSSION.

Dr. MARCET said that the Society was indebted to Mr. Mawley for working up the phenological observations, and especially for the clear and concise manner in which the report had been compiled. He recollected in the spring of last year reading a statement in the *Times* newspaper (though not in the Weather Report) to the effect that when the month of February is dry and cold the hay crop during the following season will be poor, but when February is wet and warm a good crop of hay may be expected. He wished to know whether Mr. Mawley could say if this statement was trustworthy. He remarked, with reference to accumulated temperatures, that there had been a good deal said some years back concerning the influence of these data on crops, but he had heard lately little about accumulated temperatures.

Mr. SYMONS said that he considered that the diagram of dates of flowering of plants which Mr. Mawley had prepared was interesting and instructive, for it conveyed to the minds of even those who did not possess any knowledge of phenology a clear idea of the amount of retardation in dates of flowering which the prevailing conditions of weather in 1892 had brought about. The present depressed condition of agriculture was a question which was frequently discussed, and usually bad weather was credited with being the chief cause of the unsatisfactory state of this important British industry, but he was disposed to think that large importations of foreign and colonial animal and vegetable produce were the cause rather than bad seasons. Mr. Mawley had stated that in some districts the crops were not gathered till October, but a correspondent near Malton had informed him (Mr. Symons) that some crops in that district had not

been gathered at all, their condition being such that they were not worth collecting. There seemed little doubt that agriculturists in the district from Durham to Roxburgh had experienced an extremely disastrous season for harvesting last year.

Mr. SCOTT said, regarding the accumulated temperature values referred to by Dr. Marcet, that these figures were published regularly week by week in the *Weekly Weather Report* issued by the Meteorological Office. Whether the yield of the year's crops could be measured by the amount of accumulated heat was a question which yet remained to be solved by meteorologists or agriculturists.

Capt. WILSON-BARKER inquired whether there was any relation between the migratory movements of birds and the weather in the countries from whence the birds came. He had lately noticed the rooks assembling for their "annual parliament" in his district, and on referring to an old note book had found that the birds had assembled on exactly the same date twenty years ago.

Mr. BAYARD inquired what the small figures shown in the curves distributed at the meeting were intended to represent.

Mr. MAWLEY, in reply, said that he had not gone into the question of accumulated temperature, but thought that the amount of accumulated heat would only indirectly affect the yield of corn, although it would no doubt hasten or retard the time of harvest. Changes of temperature exercised a retarding or hastening effect on plant growth in a very marked manner. He did not think that the weather experienced in February in any way affected the crop of hay in the summer, as grass makes very little growth during that month. The hay crop must of necessity be dependent upon the weather rather later in the year, especially as regarded the warmth and brightness of the spring. He thought that the arrival of migratory birds was influenced by the weather they met with when near our shores, as well as by the weather in the countries from whence they came, both causes being intimately connected with their supply of food. The figures shown in proximity to the curves of mean date of flowering in 1892 for the several districts indicated the number of stations from which observations had been received, the curve representing the mean of these observations. An explanation of the manner in which the average date (shown by the dotted line) had been obtained was given in the previous year's report. He was pleased to find that the curves for 1892 were as a rule even smoother than those for 1891.

WINTER TEMPERATURES ON MOUNTAIN SUMMITS.

By W. PIFFE BROWN.

[Received November 19th, 1892—Read February 15th, 1893.]

In the year 1867 a minimum thermometer was placed near the summit of Y Glyder fach, 4 miles east-north-east from Snowdon and 3,262 ft. above sea level, and has been regularly observed, and the lowest winter readings recorded to the present time. It is believed that this is the only thermometer exposed at such an altitude for so long a time in England or Wales.

The following table gives the lowest winter readings for each of the 25 years during which the thermometer has been in position[1]:—

1867— 8	14°·5	1880— 1.........	12°
1868— 9, 1869—70, 1870— 1	14	1881— 2...	21·5
		1882— 3.........	16
		1883— 4.........	20
1871— 2	14	1884— 5.........	26
1872— 3	13	1885— 6	17·5
1873— 4	14	1886— 7.........	18
1874— 5	18	1887— 8.........	15·75
1875— 6	15	1888— 9.........	15
1876— 7	26	1889—90.........	15
1877— 8	17	1890— 1.........	11
1878— 9	22	1891— 2.........	9
1879—80	15·5		

Average of 25 years 16°·8.

The thermometer is screened against radiation above by a large thick slab of feldspar porphyry, and on the east, west, and south by a chaos of huge blocks of the same, standing, leaning, and prostrate, many of them over 100

[1] The following are the lowest winter temperatures registered at the Royal Meteorological Society's Stations at Churchstoke, Montgomeryshire, and at Llandudno, from 1875 to 1892.—Editor.

Winters.	Churchstoke.	Llandudno.	Winters.	Churchstoke.	Llandudno.
	°	°		°	°
1875-6	15·7	22·9	1884-5	21·8	27·0
1876-7	22·8	26·3	1885-6	13·2	22·5
1877-8	23·5	28·0	1886-7	14·7	24·5
1878-9	12·2	19·1	1887-8	17·6	25·7
1879-80	13·2	23·0	1888-9	14·4	25·5
1880-1	—1·0	14·5	1889-90	16·5	25·4
1881-2	22·1	30·2	1890-1	9·2	20·0
1882-3	10·7	25·5	1891-2	8·9	22·6
1883-4	20·3	30·0			

tons in weight; while to the north a steep slope of similar blocks falls away.

Y Glyder fach is thus described by Pennant over one hundred years ago, and the description is still as accurate as it is forcible:—"The plain which forms the top is strangely covered with loose stones, like the beach of the sea, in many places crossing one another in all directions and entirely naked. Numbers of groups of stones are almost erect, sharp pointed and in sheaves; all are weather beaten, time eaten and honeycombed, and of a venerable gray colour. The elements seem to have warred against the mountain, rains have washed, lightnings torn, the very earth deserted it, and the winds make it the constant object of their fury. The shepherds make it the residence of storms, and style a part of it Carnedd-y-gwynt, or the 'Eminence of Tempests.'"

It will be observed that until 1876 the winter readings of the instrument were curiously uniform—ranging only from 14° to 18°—since then the fluctuations have been greater; twice they have been as high as 26,° and the last two years they were respectively 11° and 9,° these being the lowest readings in the twenty-five years. None of these readings are, however, low, certainly not as low as might have been expected.

These results may be owing to the instrument being generally snowed up early in the season. A moderate fall would probably by drifting soon bury the instrument and perhaps cover it until the following spring; or it may be that extreme cold, like extreme heat, does not so much occur on moderate heights as in valleys where the humidity and radiation are greater.

On mountain tops the temperature is on the whole much lower than on the plains below. This difference is far more marked in the day time than at night, in summer than in winter. In fact, in the case of severe frosts, the conditions are ordinarily reversed, and the temperature rises with height instead of falling (see Scott's *Elementary Meteorology*). In dead calms and clear skies the air descends when refrigerated on the heights to the lowest level of the valleys.

Radiation and evaporation would be comparatively little from the naked rock surface of the summit of the mountain, to what it would be were the surface covered with vegetation, and the loss of temperature from these causes would be correspondingly little. It is, however, impossible to say whether the high readings of the instrument may be accounted for in this way, or whether they are the result of its being shielded by snow. The lower readings of the last two years are curious, but they may have been owing to the instrument remaining free, or comparatively free, from snow for a time.

It is singular that in the twenty-five years there is not even one low reading. The chances that the instrument was always covered with snow when the temperature was low are, to say the least, improbable, and it may therefore be fairly assumed that some of the readings correctly give the lowest winter temperature of the station.

The observations cannot perhaps be said to have high scientific value.

They would be more interesting if they could be compared with the minimum readings for the several winters from an adjacent low level station, but even then the minimum at such station may not have been on the same day as that at the top; still the record is an addition to our knowledge of the winter temperature on mountain tops, and possesses a certain amount of interest as being the only one of the kind known to have been taken for such a period, and is submitted for what it is worth.

DISCUSSION.

THE PRESIDENT (Dr. Williams) said that he had a very distinct recollection of the Y Glyder fach, for when on a walking tour in Wales in company with his brother 33 years ago they were obliged to ascend this mountain in attempting a short cut from one valley to another, and a very unpleasant experience they had. It was excessively windy on the top, and they found the descent very uncomfortable, as well as dangerous, on account of the loose rocks and stones. He was surprised that the temperatures recorded were not lower, but probably the indications of the thermometer were influenced by a covering of snow.

Mr. SYMONS said that he had been under the impression that the thermometer on Y Glyder fach would have given lower readings. He had, however, compared them with the lowest winter temperatures registered at the Society's station at Churchstoke, in Montgomeryshire, for the period during which both records were available (1875-92), and had found a remarkable general agreement between the two stations. Commencing with the highest reading on Y Glyder fach, he had arranged the temperatures in numerical order, placing them side by side with the corresponding temperatures recorded at Churchstoke, and he had then divided the mountain observations into groups of 5° intervals, and struck an average for each group and also for the corresponding minima at Churchstoke. The result was as follows:—

Minimum on summit	24° ;	minimum at Churchstoke	20°.
" " "	18° ;	" " "	18°.
" " "	13° ;	" " "	8°.
" " "	9° ;	" " "	9°.

The comparatively large difference between the third group was due to the exceptionally low temperature of −1° at Churchstoke in January 1881. These figures seemed to show that the mountain observations have rather more value than might have been supposed, and at the very least, Mr. Brown had earned the thanks of meteorologists for his annual ascents of this mountain for so long a period. There used to be a Six's thermometer on the top of Snowdon, but whether records were kept and now obtainable he was unable to say. The late Mr. William Marshall, M.P., too, had organised an excellent station at Stang End on the slope of Hellvellyn, about 1,500 feet above sea level. With these two exceptions he believed that Mr. Brown's observations were the only ones made on mountain summits in England and Wales.

ADMIRAL MACLEAR said that the variation of temperature with elevation and exposure was a very interesting question. He was now investigating the observations at three places at Cranleigh, one on the common (200 feet above sea level), another on the spur of the neighbouring hills (600 feet above sea level), and a third in a hollow about the same height as the spur. The difference between these stations was often considerable, the minimum temperatures on one day during the present winter having been 9° on the common, 18° on the spur, and 12° in the hollow. The range of temperature in the hollow was very great, the extremes during 1892 ranging between 95° and 20°, while on the spur on the same days the maximum was 86° and the minimum 24°.

Dr. MARCET remarked that he had referred to the observations made on Ben Nevis, which was 4,404 feet above sea level, and found that the lowest minimum temperature recorded during the period 1884-9 was 6°·4 on Feb. 10th, 1889.[1]

[1] *Journal of the Scottish Meteorological Society*, Third Series, No. VII. p. 30.

This was lower than those recorded during the same years on the summit of Y Glyder fach, but perhaps this was due to the influence of snow, the thermometer on the Welsh mountain having probably been covered with snow, whereas at Ben Nevis Observatory great care is obviously taken to keep the thermometers freely exposed.

Mr. SCOTT said that from an inspection of the photographs showing the position of the thermometer on the Y Glyder fach, it did not seem likely that the instrument would itself be covered with snow, although the mouth of the cave in which it was placed might have been stopped up by drifting snow. As regarded the degree of cold experienced on mountains, it was well known that at the Col St. Théodule, near Mont Cervin, at an altitude of over 10,000 feet, the cold during winter was not extra severe, but in summer it was very intense for that season. The temperature on these mountains did not rise in summer, and in fact the mean temperature at the Col for the month of July was the lowest summer temperature hitherto recorded in the world.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

January 18th, 1893.

Ordinary Meeting.

C. THEODORE WILLIAMS, M.A., M.D., President, in the Chair.

MILES HUGH CHRISTOPHER ATKINSON, M.D., 1 Newbold Terrace, Leamington;
JAMES CHAPMAN, M.D., 23 Albany Road, Falmouth;
WILLIAM EWART, M.D., B.A., F.R.C.P., 38 Curzon Street, Mayfair, W.;
CHARLES GIBSON, M.D., L.R.C.P., Fern Villa, Harrogate;
WATSON HANMER, 22 Arcade Chambers, St. Mary's Gate, Manchester;
HENRY HERBERT HARDING, The Grove, Fishponds, near Bristol;
ARTHUR HARDWICK, M.D., Prospect House, Newquay;
EDWARD NORTON, M.D., L.R.C.P., Capel Lodge, Folkestone;
DOUGLAS ARTHUR REID, M.D., M.R.C.S., 14 The Norton, Tenby;
ARTHUR LEE BUTLER TINDALL, B.A., Surrey County School, Cranleigh; and
CHARLES JOHN WOOD, M.Inst.C.E., Cape Town,
were balloted for and duly elected Fellows of the Society.

January 18th, 1893.

Annual General Meeting.

C. THEODORE WILLIAMS, M.A., M.D., President, in the Chair.

Mr. F. GASTER and Capt. D. WILSON-BARKER were appointed Scrutineers of the Ballot for Officers and Council.

Mr. BAYARD read the Report of the Council and the Balance Sheet for the past year (p. 82).

It was proposed by the PRESIDENT, seconded by Mr. BAYARD, and resolved:—
"That the Report of the Council be received and adopted, and printed in the *Quarterly Journal*."

It was proposed by Mr. Brewin, seconded by Mr. Ellis, and resolved:—"That the thanks of the Society be given to Mr. S. W. Silver and the Hon. F. A. R. Russell for their services as Trustees for many years past."

It was proposed by Dr. Barnes, seconded by Mr. Beaufort, and resolved:—"That the thanks of the Society be given to the Officers and other Members of the Council for their services during the past year."

It was proposed by Mr. Harries, seconded by Mr. Stokes, and resolved:—"That the thanks of the Society be given to the Standing Committees and to the Auditors, and that the Committees be requested to continue their duties till the next Council Meeting."

It was proposed by the Hon. F. A. R. Russell, seconded by Admiral Maclear, and resolved:—"That the best thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers for having granted the Society free permission to hold its Meetings in the rooms of the Institution."

The President then delivered an Address on "The High Altitudes of Colorado and their Climates" (p. 65).

It was proposed by Dr. Marcet, seconded by Mr. Symons, and resolved:—"That the thanks of the Society be given to the President for his services during the past year, and for his Address, and that he be requested to allow it to be printed in the *Quarterly Journal*."

The Scrutineers declared the following gentlemen to be the Officers and Council for the ensuing year:—

President.

Charles Theodore Williams, M.A., M.D., F.R.C.P

Vice-Presidents.

Baldwin Latham, M.Inst.C.E., F.G.S.
Hon. Francis Albert Rollo Russell, M.A.
Stephen William Silver, F.R.G.S.
Henry Southall.

Treasurer.

Henry Perigal, F.R.A.S., F.R.M.S.

Secretaries.

Francis Campbell Bayard, LL.M.
George James Symons, F.R.S.

Foreign Secretary.

Robert Henry Scott, M.A., F.R.S.

Council.

Robert Barnes, M.D., F.R.C.P.
Alexander Richardson Binnie, M.Inst.C.E., F.G.S.
George Chatterton, M.A., M.Inst.C.E.
William Henry Dines, B.A.
William Ellis, F.R.A.S.
Charles Harding.
Richard Inwards, F.R A.S.
Rev. William Clement Ley, M.A.
Admiral John Pearse Maclear, R.N., F.R.G.S.
William Marcet, M.D., F.R.S., F.C.S.
Edward Mawley, F.R.H.S.
William Blomefield Tripp, M.Inst.C.E,

February 15th, 1893.

Ordinary Meeting.

C. THEODORE WILLIAMS, M.A., M.D., President, in the Chair.

JOHN HOPKYN DAVIES, M.D., Tir Caradoc, Port Talbot, Glamorganshire;
GEORGE FREDERICK DEACON, M.Inst.C.E., 32 Victoria Street, S.W.;
ARTHUR SPRY HELPS, The Knap, Great Witcombe, Gloucester; and
RUSSELL HENRY JEFFREY, B.A., Jesus College, Oxford,
were balloted for and duly elected Fellows of the Society.

The following Papers were read:—

"REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1892." By EDWARD MAWLEY, F.R.Met.Soc. (p. 124.)

"RELATION BETWEEN THE DURATION OF SUNSHINE, THE AMOUNT OF CLOUD, AND THE HEIGHT OF THE BAROMETER." By WILLIAM ELLIS, F.R.A.S. (p. 118.)

"WINTER TEMPERATURES ON MOUNTAIN SUMMITS." By W. PIFFE BROWN. (p. 148.)

CORRESPONDENCE AND NOTES.

Complimentary Dinner to Mr. H. Perigal.—A Complimentary Dinner was given by the Royal Meteorological Society, at Limmer's Hotel, on Saturday evening, April 15th, to Mr. Henry Perigal, F.R.A.S., in celebration of his 92nd birthday, and of the completion of forty years' service as Treasurer. A number of friends from other Societies with which Mr. Perigal is connected also joined in the Dinner.

The President, Dr. C. Theodore Williams, in proposing the toast of the evening, gave some interesting particulars of the Perigal family, tracing their history back to some time before the Norman Conquest. It appears that the family were of good stock and untainted with any hereditary disease, and have been remarkable for longevity. Mr. Perigal's father, who was 99¼ years when he died, was one of thirteen children, nine of whom attained respectively their 64th, 67th, 77th, 80th, 88th, 90th, 94th, 97th, and 100th year—the last five averaging 93 years 100 days. Their father and mother died in 1824, the former being nearly 90, and the latter upwards of 80 years of age. Mr. Henry Perigal was the eldest of six children, one of whom lived to the age of 85, and the youngest, Mr. Frederick Perigal, now in his 82nd year, was present at the Dinner. Mr. Perigal briefly responded to the toast, thanking all present for their congratulations and kind wishes.

The other toasts were "The Queen and Royal Family," proposed by the President; "The Royal Meteorological Society," proposed by Prof. D. E. Hughes, F.R.S., and responded to by Mr. G. J. Symons, F.R.S.; "The Royal Astronomical Society, the Physical Society, the Camera Club, and the other Societies represented," proposed by Mr. R. H. Scott, F.R.S., and responded to by Mr. G. Knott; "The President," proposed by Mr. Baldwin Latham; and "The Visitors," proposed by the President, and responded to by Mr. H. W. Christmas, Consul-General for Servia.

Rainbow Phenomena.—On January 12th, 1893, about 1 p.m., it was my privilege to observe rainbow phenomena which may be of some interest. A very gentle wind from the North-west at the rate of 14 miles an hour was carrying a light shower towards me, and a very little was falling where I stood. The sun

was a little past direct south, and the sea was smooth and clearly in view to the south, south-east, and south-west of where I stood. The clouds were cirrus mainly, with a few cirro-cumulus on the upper and clearer portion of the sky. To the south the clouds were roll cumulus of a fleecy nature, resembling small fog banks. Through the clear interspace the sun shone clearly at times.

During this small shower my attention was arrested by the brilliancy of the rainbow accompanied by a perfect secondary bow—the prettiest and most complete pair I ever beheld. Whilst observing these I noticed that just below the primary bow the violet was repeated, and on closer view a third violet bow was seen, each dimmer than the primary. The primary and secondary bows were narrower than any I can remember having closely noticed. The violet forming the second concentric bow was from one-and-a-half to twice its own breadth from the violet of the primary, and the same distance obtained between the second and third concentric violet bows. The red and orange of the second concentric bow could not be seen, as it must have overlapped the primary, which one might have expected to mar its colour. It did not, however, so far as I could observe, do so. Happening to be in the company of others at the time, I drew their attention to these phenomena, and they saw the same clearly. These violet concentric bows were brightest at the top of the arch, and gradually faded on both sides as they approached the horizon. The second bow was from one-third to half the length of the primary, whilst the third violet bow was about half the length of the second.—M. SPENCE, Deerness, Kirkwall.

Remarkable Rainfall in Queensland, February 1st-4th, 1893.—I send a few particulars of the recent remarkable rainfall at Crohamhurst, situated on the western slope of Mont Blanc, a park on a spur of the D'Aguilar range, an offset from the Blackall ranges, South Eastern Queensland. The whole of this district is watered by the Stanley River, a tributary of the Brisbane River, and hence the values given below were prominent factors in producing the terrible floods from which we have suffered. I may mention that the observer at Crohamhurst is Mr. Inigo Owen Jones, one of my specially trained assistants, and that implicit reliance can be placed on his figures.

The following are the more phenomenal falls of the flood period at Crohamhurst:

for 24 hours ending	9 a.m.	February	1st	10·775	ins.
"	"	"	2nd	20·056	"
"	"	"	3rd	35·714	"
"	"	"	4th	10·760	"

The gauge is a standard of the "eight inch" pattern, standing one foot above the ground at an altitude of 1,400 feet above mean sea-level. The approximate latitude and longitude of Crohamhurst are 26° 50′ S, 152° 55′ E. The gauge was emptied every three hours, night and day, on the occasion of the greatest fall. I think meteorologists will agree that for a 24 hours fall we have beaten the world's record.—CLEMENT L. WRAGGE, Government Meteorologist of Queensland.

The Moment of Freezing.—An interesting illustration of the release of latent and its conversion into sensible heat, was exhibited under the following circumstances:—On a cold evening I was observing the temperature by the dry and wet bulb thermometer (Feb. 27th, 1893). The water in the cup which supplied the moisture to the wet bulb was unfrozen, though the temperature by both dry and wet was 26°·5. Having registered the temperature, I touched the cup with my fingers for a moment, with the result that crystals of ice immediately shot out from all sides, and with a slight crackling noise the whole contents of the cup solidified.[1] At the same moment the wet bulb thermometer rose suddenly about six degrees, and so remained for a few minutes. The latent heat rendered sensible by freezing, either through the atmosphere (the distance of water from bulb was nearly 2 ins.) or through the thread, raised the temperature from 26°·5 to freezing point. Ten minutes afterwards I found the wet bulb still read 3°·5 above the dry.—Archdeacon G. R. WYNNE, Killarney.

1 "Solidified" means that the water became one thick mass of needle-like crystals; it was not a block of ice for some time after.

Frost at Hong Kong, January 16th-18th, 1893.—We have been favoured by the Colonial Office with some particulars on the subject of the exceptionally severe weather experienced at Hong Kong in January, together with some photographs illustrative of the appearance of some parts of the hill during the frost.

On Sunday, the 15th, the temperature recorded at the Observatory was 38°, and Tai-mo-shan and the range of hills to the westward were covered with snow, or with a coating of icicles on the grass which had the appearance of snow. During the night the thermometer continued to fall steadily, the temperature at 10 a.m. on Monday being 33°, while at the Peak readings as low as 27° were reported. Rain fell at frequent intervals and froze as it fell, ice being observed at as low an altitude as 450 feet. In the hill district the roads were coated with frozen slush and in steep places were almost impassable. The light telephone wires were borne down by the weight of the ice resting upon them, and in places even the thicker telegraph wires were broken. On Tuesday, the 19th, the weather was even more bitter and frosty than on the preceding day. The Peak was again enveloped in a thin veiling of ice and hoar-frost, and although no rain or snow fell the sky wore all the appearances of a thoroughly wintry day. Ice in large quantities was brought down to the lower levels, and scores of Chinamen were seen carrying pieces of twig and leafy branches covered with curious icicles, which were evidently regarded by them as phenomena worthy of exhibition and remark. The temperature at the Peak during the night fell to 25°, and in the harbour one or two degrees of frost were registered. The hills on the mainland still wore an irregular garment of white on their summits.

Similar severe weather was also experienced at Canton and Macao, icicles hanging from the eaves of the houses in the town, and the surrounding hills being covered with snow. The wind blew very strongly from the Northward.

Meteorological Conference at Washington, 1893.—It is proposed to hold an International Conference of Meteorologists at Washington, on July 26th, 1893. Prof. M. W. Harrington, the Chief of the Weather Bureau, has issued the following provisional programme of topics to be discussed by the Conference:—

(*a*) The organisation of additional meteorological work for the benefit of agriculture.

(*b*) The extension to all ports frequented by commerce of the benefits of systematic storm and weather signals, and the introduction of a uniform system of storm warnings throughout the world.

(*c*) The co-operation of all nations in the publication of a daily chart of the weather over all the habited lands and frequented oceans for the study of the atmosphere as a whole and as preparatory to the eventual possibility of predicting important changes several days in advance.

(*d*) The equable apportionment of stations, publications, and expenses among the nations, and the suggestion of practical methods by which to secure observations from those countries that are not represented in this Conference.

(*e*) The encouragement by the respective Governments of special scientific investigations looking to the advancement of Meteorology.

(*f*) The consideration of such other matters as the delegates may think advisable to submit for discussion or for future report.

Arrangements will be made to enable delegates to inspect Pike's Peak and other typical stations of the Weather Bureau.

In every respect it is desired to make this Conference valuable to agricultural and international interests, and auxiliary to such as have been held in Europe.

International Congress of Hydrology and Climatology, Rome, September 24th-October 1st, 1893.—The third Session of the International Congress of Hydrology and Climatology will be held in Rome at the same time that the 11th Medical International Congress will be open, and will form the 19th section of that Congress, with its own denomination.

The International Congress of Hydrology and Climatology, which was to have been inaugurated in Rome in 1892, was postponed until 1893 by the authorisation of the Members of the Committee of the International Congress of Paris in order to fall in with the 11th Medical International Congress, which was to be held in Rome a year later.

It would have been unfortunate if the Hydrological Congress, after having been put off for a year, should not be held afterwards at the same time as the Medical International Congress. This idea had been broached by the esteemed Professors Grocco and Winternitz, at the yearly union of the Medical Italian Association of Hydrology and Climatology held in November last in Florence, promoting an order of the day by which the Presidency of the association was invited to treat with the Committee of the 11th Medical International Congress, so that the two Congresses might be held together in Rome.

The matter has now been arranged, and the third Session of the International Hydrological and Climatological Congress will form part of the 11th Medical International Congress.

The members of the Hydrological Congress will enjoy the same privileges and will have the same duties as the members of the Medical Congress.

The subscription fee has been raised to 25 francs, but the Hydrological members, besides the proceedings of the third section of the Hydrological Congress, will also receive those of the other sections of the Medical Congress, and will enjoy the same facilities as are accorded to the other members.

Cloud Heights and Velocities.—During the last five years observations for determining cloud heights and velocities have been made at the Blue Hill Observatory, Mass., U.S., by Messrs. H. H. Clayton and S. P. Fergusson. One of the most noticeable things brought out by these measurements is the difference in height between the same cloud forms in summer and winter, the clouds with few exceptions being found lowest in winter. The greatest difference in height between summer and winter is in the highest clouds, and the difference gradually diminishes down to the lowest clouds. It appears from the altitudes of the highest clouds measured at Upsala, Kew, and Blue Hill, that the upper limit of ordinary clouds in temperate latitudes is about 9 miles; but it is possible that more numerous measurements may extend it to 10 miles.

The mean cloud velocities at Blue Hill indicate that the entire atmosphere, from the lowest to the highest cloud level, moves almost twice as fast in winter as in summer. The mean velocity of the highest clouds is over 50 metres per second, or 100 miles an hour; and the highest velocity, 103 metres per second, or 230 miles an hour, shows that the upper currents sometimes move with enormous velocities.

Barometric Waves.—The Rev. J. Scoles, S.J., of St. Ignatius' College, Malta, has made an examination of the barometric waves during the last ten years, which he carried out in the hope that the result might throw some light on the three day period, popularly attributed in Malta to the gales of wind, and very frequently verified in fact. He also expected to find a difference between the summer and winter behaviour of the barometer, and he thinks he has succeeded in both. He reckoned the waves from minimum to minimum from a tabulation of the 8 a.m. and 8 p.m. readings, but eliminating movements or dips of less than 0·1 inch deep.

From the results it appears that the depressions average 6¼ days in passing, and the winds of one side may be expected to come near averaging 3 days in duration, or sufficiently so to attract notice to the period. Very frequently only the winds belonging to one side of a depression prevail, and generally it is the rising side that is windy. Comparing the summer half with the winter half, there is a considerable contrast to be seen. The summer depressions average 1·7 day more in length and 0·16 in. less in depth than the winter ones, so that the motion of the barometer is twice as lively in the winter half. April is a remarkable month for short period. In summer, especially in June and July, when the weather is very fine, there is a constant difference between the 8 a.m. and 8 p.m. reading of from 0·03 to 0·05 in. in favour of the morning reading, the result of diurnal variation. This is seldom seen in winter, or indeed after August.

Thunderstorm in the Red Sea, January 1893.—Mr. H. M. Lambert, Lieut. R.N.R., of the P. and O. s.s. *Coromandel*, has sent the following notes taken during a severe thunderstorm in the Red Sea in January last. Mr. Lambert, who has had upwards of fourteen years' experience of voyages through the Red Sea, and at one time spent nearly twelve months there, considers the weather, and especially the vivid lightning, to be exceptional:—

"Left Port Said, and entered the Suez Canal at 8.40 p.m., January 5th, with the wind East-south-east (force 4). Weather cloudy with incessant lightning from all quarters, and frequent downpours of heavy rain. This weather continued until 11.30 a.m. on the following day, when it cleared up for about an hour, after which frequent squalls with rain were experienced until arrival at Suez (5 p.m.).

"On leaving Suez the same evening, the wind was South (force 5), with violent squalls of wind and rain. The night was very dark; but lit up with frequent brilliant flashes of sheet lightning, which illuminated the land for a great distance all round.

"Off Asmafi the wind rapidly decreased, and it became calm. This lasted for 5 hours, and when off Shadwan the Southerly wind again sprung up, and when off the Brothers a heavy Southerly swell was also experienced. Throughout the night the lightning was very brilliant from all quarters.

"At daylight the next day (January 8th) the wind was South-by-west (force 6), with hard squalls and considerable sea.

"At 11 a.m. the wind was West by North (force 6)
" 1 p.m. " " " North-west (force 5·6)
" 10 p.m. " " " North-north-east (force 5)

with north-easterly sea, and high south-easterly swell, weather being overcast with incessant vivid lightning.

"On January 9th, at noon, the wind shifted to South-east-by-east (force 5 to 6), with hard squalls and heavy thick rain, and as night closed in the squalls increased in violence with deluging rain and lightning all round.

"At 2 a.m. (January 10th), the wind being South (force 3) two thunderstorms were observed nearing the ship—one coming from the north-west, and the other from the south-east. The former reached the ship first, and a few minutes later the two storms had met each other, leaving an arch of clear weather right ahead (S 33° E). My attention was particularly drawn to the distinctive character of the lightning in each of these storms, for although they remained for 5 hours in close proximity, and apparently in contact, there was a marked difference in the lightning throughout. In the western storm the lightning was horizontal, slightly inclined downwards, forked, chain, and sheet; but in the eastern storm the lightning shot up in jagged streaks from the horizon. The wind was very unsteady, blowing from all quarters. The rain descended in torrents with tremendous force, making the sea spout up in all directions. At 6.10 a.m. a very vivid flash of lightning, which seemed to envelope the ship and come from both storms, occurred, and instantaneously the thunder crashed overhead with a succession of sharp loud reports. The native crew were much frightened, and several glass insulators were found on deck. At 6.15 a.m. a few pale long beams of light appeared to the southward, stretching upwards from the horizon; but only lasting about a minute.

"There was no St. Elmo's fire. Several grey moths with black stripes were seen. The compasses were not affected. At 7.20 a.m. the weather commenced to clear, and the rain to cease.

"At noon the wind was fresh from the Southward, and fine weather with moderate sea was experienced to Perim."

Meteorological Observations in Eastern Africa.—The Rev. W. Morris, of the Church Missionary Society, has made observations of temperature at Mochi, on the southern slope of Kilimanjaro, 5,000 feet above the sea, and at Sagalla in the Taita mountains, 3,500 feet. The mean annual temperature of Mochi is 65° (June and July 60°, December and February 60°). The diurnal range amounts to 16°, and is most considerable in October and February (20°), least from April to July (16°). On no single occasion, during the whole of the year, did the temperature rise above 82°, nor did it ever sink below 70°. Rain falls in every month, but is heaviest in April and May, and again from November to January, the total for the year apparently not exceeding 40 ins.

At Sagalla, half-way between Kilimanjaro and the coast, the observations extend over ten months. The mean annual temperature is about 72°; the mean diurnal range 21°; the extremes recorded were 96° and 54°.

Climate of New South Wales.—Mr. H. C. Russell, F.R.S., in the second edition of his work *Physical Geography and Climate of New South Wales*, states that the colony has the most enjoyable climate, because it is beyond the limits of tropical heat, and yet within the influence of offsets from the Trade Winds, which in summer blow upon the coast districts and make the temperature much lower than might be looked for in this latitude, and much lower than is experienced in corresponding latitudes in Europe. It seems that in works of reference, Australia generally is credited with heat in excess of that due to its latitude. Mr. Russell quotes the temperature records of a number of stations in the colony, and shows that they compare favourably with stations in Europe. Sydney, in latitude 34°, has a summer temperature only 4° warmer than Paris, which is in latitude 49°. The usual difference for a degree in latitude is 1° in temperature, and therefore, if Sydney were as much warmer than Paris as its latitude alone would lead us to expect, its temperature should be 74°, *i.e.* 15° warmer than Paris, whereas it is only 4° warmer.

The mean temperature of the colony, based on observations made at forty-five stations is 59°·5.

The highest shade temperature recorded at Sydney was 106°·9, and the lowest 36°8.

The western plains are subject to greater heat, caused no doubt by the sun's great power on treeless plains, and the almost total absence of cooling winds; and the air is also remarkably dry.

The rainfall along the coast districts is very abundant, ranging from 45 ins. at Eden to 76 ins. at Tweed River in the extreme north. At Sydney it is 50 ins. Along the top of the mountains the rainfall is from 30 to 40 ins., on the western slopes from 20 to 30 ins., and over the flat country from 10 to 20 ins.

The coast rains are often tropical in their character, and deposit water in such abundance on the face of the mountains as to feed many rivers; but these rains on the abrupt rise of the mountains run down so rapidly that floods frequently result, and are now and then dangerous. The coast and the mountain rains come from the eastward. The clouds coming in from the sea at a small altitude deposit abundant rains as they travel over the mountains, for as they rise in obedience to well-known laws they drop nearly the whole of their rain, and then having passed over, as they descend they become gradually dry clouds over the western plains; but when the force of the easterly current is over, and these clouds become subject to the usual drift from west to east, they have again to rise over the mountains, and in doing so deposit moisture; hence it is that the western districts get a great deal of rain with Westerly winds. In the northern districts tropical rains sometimes come from north-west or north-east.

Severe Weather in the Atlantic, December 1892.—The *Pilot Chart of the North Atlantic Ocean* for February 1893 contains a map illustrating graphically the great size and severity of the hurricane of December 22nd, 1892, which covered the entire Atlantic from Labrador and Nova Scotia to Madeira, Portugal, and Ireland. A specially interesting feature of this storm is the fact that it has furnished some of the lowest reliable barometer readings ever reported from the North Atlantic. One of the lowest readings was 27·75 ins. observed on board the Netherlands-American steamer *Werkendam*, in lat. 39°·41′ N. and long. 30°·41′ W.

All vessels arriving at New York from Europe reported having experienced fierce storms, accompanied with intense cold. The deck of the *Laurestina*, from Bremen, was covered with ice, which in some places was 2 ft. thick. The vessel's three compasses all froze in alcohol baths. The French Transatlantic Company's steamer *La Normandie* arrived in harbour looking like a vessel from the Arctic Regions, being covered with ice from stem to stern.

Wrecks in the North Atlantic.—The U.S. Hydrographic Office has published a chart for the period of five years 1887-91, on which is graphically shown the localities where 956 vessels were wrecked on the Atlantic coast of North America, together with the positions of 332 abandoned vessels, of which 139 were frequently reported and have their drift tracks plotted as far as the limits of the chart will permit. In addition to these the *Monthly Pilot Charts* and *Weekly Bulletins* show that there were in this same region and period 625

derelicts which could not be identified. These 625 unknown, with the 332 known derelicts make a total of 957 derelicts during the five years, or an average of 16 for each month. A table of the drift of derelicts indicates, as far as can be estimated from the number of days these derelicts were floating, that the average time a derelict remains afloat is about 30 days, so that it is evident that there are at least 16 derelicts constantly afloat in this region. This average is probably under-estimated, since it is based only on definite reliable reports, and no doubt there are many more which were not reported or were not seen. The *Pilot Chart* for February 1893, shows 45 derelicts afloat in the North Atlantic, 25 of which were in the vicinity of the tracks of the transatlantic steamers.

Lieut.-Commander Clover, the Hydrographer, states that the most reliable statistics show an average annual total loss of 2,172 vessels with 12,000 lives in the commerce of the world. The estimated value of the vessels and cargoes lost is about one hundred million dollars.

Climate of South-eastern Alaska.—Prof. J. J. Stevenson, in a paper in the *Scottish Geographical Magazine*, Vol. IX. p. 66, says that the climate of South-eastern Alaska, between 54°·40′ and 58°·10′ N. lat., is a source of constant surprise to visitors from the Atlantic slope. It is true that Wrangel, at 56°·30′ N, is but a few miles north of Edinburgh; that Sitka, at 57° N, is more than ten miles south of Aberdeen, and that Juneau is twenty miles south of Pentland Firth; but on the Atlantic coast of North America the same parallels pass through bleak and dismal Labrador, while on Hudson's Bay, at 57° N, lies Fort York, where the summer heat penetrates but a few feet below the surface. Yet on this west coast trees grow three thousand feet above the sea at Wrangel, and up to the mountain tops at Juneau. The rainfall is great, amounting to 103 ins. at Juneau, though it is less at Sitka directly on the ocean. The variation in temperature is not great; the mercury rarely falls below ten degrees above zero at Sitka, and as seldom rises above 75°. The extremes are much greater on the mainland beyond the mountains, where the summer heat and winter cold are much more intense than immediately on the coast.

The remarkable contrast between the Atlantic and Pacific coasts of North America is due to the influence of the Kuro Siwo, or great Japanese current, which is similar to that of the Gulf Stream upon the west coast of Europe. And there are many points of resemblance between the two streams. The Japanese current is divided by a cold northern current at about N. lat. 38°, and E. long. 150°, and fogs are produced by the contact, as they are when the Gulf Stream meets the Labrador current in the North Atlantic. The Kamschatka or northerly branch flows into Behring's Sea and passes through Behring's Strait into the Arctic Ocean, first striking the coast of Northern Alaska: the mild climate of that coast is due to it, and possibly its influence on the ocean temperature has much to do with the presence of fur-seals in Behring's Sea. The main body of the stream crosses the ocean and reaches the American coast not far from the Straits of San Juan de Fuca, whence it flows southward to join the Great Northern Equatorial Current off Lower California. Many years ago, a junk with a cargo of beeswax was wrecked at the mouth of the Columbia River, and to this day pieces of wax are thrown on the shore during severe storms. In 1833 a Japanese junk was wrecked off Cape Flattery, and in the early "sixties" another was found in mid ocean by an American vessel on which the crew were taken to San Francisco. Distinct proof of a northerly branch from the main body is wanting; but currents exist along the Alaskan coast the relations of which are perplexing, and would be explained best by the existence of such a northerly branch, with such eddies as must result from the configuration of the coast. It is said that a Japanese junk was blown into Sitka Harbour about seventy-five years ago and wrecked. The conditions at Sitka suggest the presence of a warm current not very far off to the west, for the average rainfall during fourteen years was 83·39 ins., the rainy days being 245 per annum. The temperature of the surface water at Sitka during August 1867 was 50°·5, the temperature of the air averaging 53°·4; but in October, when the cold weather from the snows was coming down, the surface temperature had fallen to 41°, while that of the air was 44°.

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SOME METEOROLOGICAL PROBLEMS.

By SHELFORD BIDWELL, M.A., LL.B., F.R.S.

A Lecture delivered before the Royal Meteorological Society, March 15th, 1893.

It was not without hesitation that I accepted the invitation with which I was honoured by your Council to deliver a Lecture here this evening. I have no pretensions to be a meteorologist, and my acquaintance with the science is unfortunately of a very meagre and imperfect description. But it has happened that in the course of my study of another science, that of Physics, I have from time to time come across certain facts and phenomena, some old, others more or less new, which seem to have a bearing upon meteorological questions, and I thought it might be of interest if I brought some of them to your notice, illustrating my remarks as far as possible by experiments.

Atmospheric Electricity.—One of the earliest problems connected with the science, and one which remains unsolved to the present day, concerns the origin of atmospheric electricity. All meteorologists are familiar with the fact that the potential of the air is in general very different from that of the

earth, the air, or at least large bodies of it, being in a state of electrification —generally positive, sometimes negative—with regard to the earth; and every one is familiar with the electrical effects which are occasionally presented by a thunderstorm. But how the electrical condition is set up no one knows exactly, nor has anything been yet advanced which explains the matter satisfactorily. Among the causes which have been suggested may be mentioned the evaporation of water, the chemical action attending the growth of vegetation, the friction of air, especially when dust-laden, against the earth, and the friction of particles of ice against particles of water in the clouds and upper regions of the atmosphere.

The first named of these possible causes, evaporation, which was also one of the earliest suggested, has had many supporters. There is no doubt whatever that violent evaporation is accompanied by electrical action, as may easily be shown by a very old experiment.

There is projected upon the screen the image of an ordinary gold leaf electroscope. The two pieces of gold leaf are seen to hang side by side and close together from a conducting block of brass, the arrangement forming a somewhat sensitive apparatus for the detection of electrification. Thus, if a stick of sealing wax, electrified by friction with flannel, is held near the instrument, the two gold leaves at once fly apart, their movement being due to mutual repulsion and giving evidence of electrification. A small tin pan containing some hot sand is now connected with the electroscope, and a few drops of water in which a little salt has been dissolved are poured upon the sand. Instantly the two gold leaves separate from each other, showing that the sand has become electrified—negatively, as we see by testing with the sealing wax, and therefore that the vapour which ascended was electrified positively.

It will be noticed that this effect occurs only while the water is actually boiling: when the sand is not hot enough to make the water boil there are no longer any signs of electrification. It has been objected, therefore, that the electrification is not really produced by evaporation, but by the friction of small particles of ejected water, as in Armstrong's well-known hydro-electric machine. There is, however, reason to believe that electrical action does really occur at lower temperatures. Using a quadrant electrometer, which is a far more sensitive instrument than the gold leaf electroscope, I have found measurable effects even when the temperature of the moist sand had fallen to as low a point as 50° C: and it appears from the experiments of Prof. Palmieri that appreciable electrification is produced when sea water contained in a small vessel is evaporated merely by the heat of the sun's rays.

It is possible that more causes than one are operative in producing atmospheric electrification. The friction of the air against the earth, especially if dust laden, might have a powerful effect. How small an amount of friction is competent to produce sensible electrification may be shown in a striking manner by an experiment, which, though almost childishly simple, is I believe quite unknown. I have here a glass flask containing an ounce or

two of dry sand. Holding the flask at a short distance above an insulated metal tray connected with the electroscope, I slowly pour the sand into the tray. The gold leaves, as you see, immediately begin to diverge, and in a few seconds become widely separated, the electrification being, as before, negative. The effect is no doubt to be attributed to the friction of the outflowing sand against the neck of the glass bottle. This experiment would lead us to expect that clouds of dust raised by the wind would be found to be electrified, and from observations made in the United States and referred to in *Nature* a week or two ago, this appears to be the case.

Whatever the true cause or causes of atmospheric electrification may be, there is little doubt that our knowledge on the subject might be vastly increased by the aid of suitable experiments made upon a sufficiently large scale. The resources of an ordinary laboratory are inadequate, and, as Prof. Tait has said, the difficulties will probably be easily overcome by the first nation which will go to the expense of providing the necessary means.

Thunderstorms.—Having granted some sufficient source of electrification, most of the ordinary phenomena of thunderstorms become easily intelligible. It was suspected nearly 200 years ago that the flashes of light and crackling sounds produced when a glass rod was rubbed with a piece of silk were of the same nature as lightning and thunder, and after the invention of the electrical machine and the Leyden jar this idea received strong confirmation. The apparatus that I have on the table is rather small for demonstration before an audience, yet the effects of light and sound that attend the discharge of these two half-gallon Leyden jars cannot fail to suggest to the most unimaginative mind the phenomena of thunder and lightning. The essential identity of the artificial electric spark with the natural lightning flash was conclusively established by the famous kite flying experiments of Franklin, and in these days we are apt to forget that there was ever room for doubt on the subject.

Lightning Flashes.—We are indebted in part to recent improvements in the art of photography, and in part to the energy of the Council of this Society in collecting and drawing attention to lightning photographs, for a very complete revolution in our notions as to the form of a flash of lightning. Artists have hitherto been accustomed to indicate lightning by a kind of conventional symbol, which bears no resemblance whatever to anything in nature. The symbol generally takes the form of a number of perfectly straight lines arranged in a zig-zag, such as you see in the example of what may be called artistic lightning which is now projected upon the screen.

The various forms of real lightning flashes, as revealed by photography, are no doubt familiar to most Fellows of the Royal Meteorological Society, and I will not detain you by exhibiting more than a few specimens. What may be called a normal lightning flash is a stream of light which takes a sinuous and wavering course, very like that of a river as shown upon a map: it rarely happens that any considerable portion of the stream is perfectly straight. [Three photographs of normal flashes were shown upon the screen.]

The next photograph represents a spark about three inches in length, given by a small electrical machine. Its resemblance to the lightning flashes is very striking.

Photographs show that the normal type of flash is subject to several modifications. These have been classed as branched, beaded, meandering or knotted, ribbon, and "dark" lightning.

A branched or ramified flash occurs probably when the electrical discharge is incomplete, and consequently feeble. The appearance along a flash of a number of lustrous beads, really due to abrupt V-shaped indentations, seems on the other hand to indicate a discharge of unusual density; a similar appearance being often seen in a machine spark when the distance between the terminals is short and large Leyden jars are used. The so-called "meandering" variety, presenting sometimes the form of a nearly closed loop, or even a complete knot, owes its curious feature simply to an optical illusion: it occurs when the general direction of the discharge is in the observer's line of vision, and the different portions which seem to approach or cross each other may, in fact, be very far apart. The broad or ribbon-like form which distinguishes some photographs of lightning is to be attributed to unsteadiness of the camera, but the effect would only be produced in cases where there happened to be a multiple discharge, a series of two or more flashes taking exactly the same path. The effect of a very narrow ribbon may, however, sometimes be due to successive reflections between the surfaces of the lenses or sides of the sensitive plate. Photographs of the machine spark exhibit a similar phenomenon when the light is made to fall obliquely upon the lens, one edge of the image being in such cases quite sharp and the other hazy and ill-defined. The "dark" or black flash seen in many photographs has been shown by Mr. Clayden to be the result of a chemical or photographic action. If the sensitive plate has been exposed to the action of light after the image of a flash has been impressed upon it, this image will on development often come out black instead of white. Such a reversal never takes place if the camera lens is covered immediately after the occurrence of a flash. [Lantern photographs of various forms of lightning and machine sparks were exhibited.]

It is not always very easy to distinguish the form of a lightning flash, on account partly of its brilliancy and partly of its extremely short duration. Perhaps this is the reason why common notions on the subject are so vague and erroneous. Even a bright machine spark, when looked at directly, presents the same difficulty to some extent, and its peculiarities are more easily observed if it is looked at through a piece of tinted glass, or if it image is projected by means of a lens upon a screen.

I have here an arrangement for doing this, and the result with a series discharges from large Leyden jars is very striking. The similarity of t luminous images upon the screen to the lightning flashes, as represente the photographs, must be evident to all. I believe this beautiful experin was first publicly exhibited by your former President, Dr. Marcet.

Another way of showing the form of the discharge upon a large scal with correspondingly diminished brightness is afforded by the pie

apparatus now before you, which has been called a "lightning board." The board, which is about five feet in length, is covered on one side with tinfoil, divided into little pieces about $\frac{1}{16}$ inch square by longitudinal and transverse cuts; or the board may be covered, as suggested by Mr. Wimshurst, with the material known as bronze paper. A machine which will give a spark not more than an inch or two long in air will produce a discharge along the whole length of the board, its form, as before, bearing a remarkable resemblance to that of lightning. A board prepared in a somewhat similar manner and coated with a suitable phosphorescent substance, such as sulphide of calcium, affords us the means of illustrating in a crude but effective manner the phosphorescence which seems to be exhibited by air through which a lightning flash has passed.[1]

Duration of Flash.—Although the duration of a single flash of lightning appears to the eye never to be less than an eighth or tenth part of a second, this appearance is illusory. It is caused by what is known as the persistence of vision, in virtue of which a sufficiently strong luminous impression will continue for a certain time after the exciting cause has ceased to act. In spite of ocular evidence to the contrary, there is excellent reason for believing that a single lightning discharge is always completed in less than the ten-thousandth part of a second. This is proved by observations made with an instrument like that before you. It consists of a disc of metal or cardboard divided radially into a number of equal parts, which are painted alternately black and white. When this disc is caused to rotate rapidly, it appears in a steady light to be of a uniform gray colour; but when viewed by the illumination of a lightning flash, the separate sectors are seen as clearly and distinctly as if the disc were at rest. Only when the rotation is so rapid that the disc makes about 200 turns in a seecond, the lines of demarcation between the black and white portions appear to be blurred, showing that although the period of illumination is exceedingly short, the flash is not absolutely instantaneous.

We may repeat this experiment with the light afforded by the Leyden jar discharge, and it will be seen that with every spark that passes the black and white partitions of the revolving disc flash out with startling distinctness, just as if the motion had for an instant altogether ceased. The fact is that the disc had not time to move perceptibly during the exceedingly brief period of illumination which the spark afforded.

Flicker of Lightning.—The quivering or flickering character of the illumination produced by a lightning flash must have been noticed by every one. This peculiar effect is often due to the multiple discharge, of which mention has already been made. The first flash seems to cause a temporary diminution of the resistance of the air along its path, and exactly the same path is accordingly taken by two or three more flashes in rapid succession. Sometimes, however, I believe the phenomenon is a purely subjective one, depend-

[1] Mr. Clayden has suggested that this apparent phosphorescence may be due to the burning of nitrogen. Prof. Dewar has, however, shown that oxygen is a phosphorescent substance.

pon a certain physiological reaction of the optic nerve. If we extinguish amps in a room which is brightly illuminated by the electric light, after a short interval of darkness, lasting for rather less than a second, we ı become conscious of a feeble luminosity which may endure for another tion of a second. I notice this every night when I put out the electric ıps in my bedroom. Or if we gaze at a gas flame and then suddenly turn ›ut, a distinct but transient image of the flame will in a short time re-pear. It is, however, by no means easy to detect these effects without actice, because they belong to a class of impressions which we habitually ain ourselves to disregard. But by means of a little device which I pub-ıshed a few years ago, they may be easily demonstrated to almost any one.

The apparatus used for the purpose is upon the table. It consists of a vacuum tube mounted in the usual way upon a horizontal axis capable of rotation. The tube is illuminated by a rapid succession of discharges from an induction coil, and when the axis is turned quickly the images due to the separate discharges, which, if the tube were at rest, would be superposed and appear as one, are caused to occupy different portions of the retina, the result being the well known appearance of a gorgeous revolving star. But if the tube is made to rotate very slowly, at the rate of about one turn in two or three seconds, there occurs a different and very curious phenomenon. The luminous images of the tube are now almost superposed, forming a bunch which is slightly spread out at the two ends. But about 40° behind the bunch, and separated from it by a clear space of darkness, comes a ghost. This ghost is in shape an exact reproduction of the tube. It is very clearly defined, and though its luminosity is feeble, it can no doubt be easily seen by most of those present. The varied colours of the original are, however, lost, the whole of the phantom tube being of a uniform gray tint. If the rotation is stopped the ghost still moves steadily on, until it reaches the luminous tube, with which it coalesces and so disappears.

It is hardly necessary to point out that the phenomenon of the ghost is due to a succession of after-images which are perceived a short time after the retina has been impressed by the flashes from the vacuum tube, and a similar physiological action, I think, explains in many cases the apparent reduplication of a single flash of lightning.

Lightning Conductors.—Ever since the time of Franklin it has been customary to make use of long, pointed metallic rods for the purpose of protecting important buildings from damage by lightning, and until a year or two ago, when the question was taken up by Dr. Lodge, it was always taught by the "older electricians," as he calls them, that a lightning rod, if well made, of sufficient size and height and properly connected to earth, afforded practically perfect security over a limited area. The function of the rod was supposed to be not so much to receive the shock of a lightning flash as to prevent a flash from occurring at all in the neighbourhood of the protected building, by promoting the silent discharge of electricity between the storm cloud and the earth.

Before me are two wooden boards covered with tinfoil. One rests upon the

table, from which, however, it is insulated: this we will take to represent the earth. The other is supported horizontally by glass rods at a distance of about a foot above the first: this represents a cloud. The earth and the cloud are respectively connected with the two terminals of the Wimshurst electrical machine: each terminal of the machine is also connected with the inner coating of a large Leyden jar, the outer coatings of the two jars being joined together by a piece of wire. We proceed, in Lodge's manner, to erect a building upon the earth. This we do by placing upon the lower board a little article formed of a piece of brass rod having a brass ball attached to one of its ends and a wooden foot to the other. The rod stands in an upright position upon the foot, the total height from ball to foot being about seven inches. We may, if we please, suppose this to be a church steeple. When now we work the Wimshurst machine we get a series of powerful and noisy flashes passing between the cloud and the steeple, each of which might do terrible damage.

But if we place near the steeple another upright rod having a needle point at its upper end, to serve as a lightning conductor, the flashes at once cease. However vigorously we work the machine there is no longer any visible effect. The fact is that all the electricity is silently and harmlessly discharged as quickly as it is generated. In such a case as is at present represented by this model, the efficacy of a lightning conductor would be complete. This is what Dr. Lodge calls the case of "steady strain," and it occurs when the thunder cloud has moved from a distance into its position above the steeple, so that the strain in the air has been of gradual growth. This, according to Dr. Lodge, is the only kind of lightning discharge which was ever contemplated by the older electricians.

But suppose that a harmless uncharged cloud which might be hovering above the steeple were to suddenly receive an overflowing charge by a flash from another more distant cloud. There would then be no time for any gradual relief of the strain by means of the lightning conductor, and either the steeple or the conductor itself would infallibly be struck by a flash from the overflowing cloud.

We can easily imitate this condition of things by altering the electrical connections in our model. We join the cloud and the earth to the outer instead of the inner coatings of the Leyden jars, and substitute a wet string for the brass rod connecting their outer coatings. We also bring the discharging terminals of the machine within two or three inches of each other. And now when the handle is turned no electricity whatever passes to the tinfoil covered boards until the moment when there is a spark between the terminals of the machine: then the two boards become instantly charged, and are as instantly discharged by a flash between the steeple and the cloud. With every spark that you see between the terminals the steeple sustains a lightning stroke. Placing the needle-pointed lightning rod beside the steeple, we now find that it is powerless to prevent the flashes: they go on just as rapidly as before, striking sometimes the steeple, sometimes the lightning rod, sometimes both at once. This case, which I think Dr. Lodge was un-

doubtedly the first to call attention to in connection with thunderstorms, is called by him the case of "impulsive rush."

The occurrence of an "impulsive rush" flash then cannot be warded off by a lightning rod. The most that such a rod can do is to divert the shock of the discharge from the building to itself. But even so the lightning may do considerable damage; because a conductor cannot possibly be made so much the easiest path that all others are protected. A disruptive discharge of electricity is far from being subject to the laws of resistance which apply to steady currents.

Mr. Preece, who claims to be personally acquainted with half-a-million lightning conductors, warmly opposed the views of Dr. Lodge when they were first put forward; and has returned to the charge in his recent Presidential Address to the Institution of Electrical Engineers. "Dr. Lodge's views," he says, "have not received general acceptance, for they are contrary to fact and to experience." No doubt Dr. Lodge will have something to say to this in due course.[1]

Meantime the conclusion appears to be this. In all cases of "steady strain," in which a charged cloud approaching from a distance might inflict serious injury upon an unprotected building, a well made and properly earthed lightning rod of the ordinary form constitutes an absolute safeguard.

In a case of "impulsive rush" (if such a thing is possible in nature, as I think cannot be doubted) the lightning rod may often be of use in bearing the brunt of the discharge, though sometimes the lightning will take no notice whatever of it, striking the building and altogether neglecting the rod; and it is even possible that a high rod might attract or determine a destructive discharge, which without its presence might not have occurred at all. Although, therefore, such a rod may in many cases, probably in a large majority, be of the greatest service, it cannot be depended upon as affording perfect immunity from risk, and the assumption always made by the "older electricians" that damage by lightning is in itself conclusive evidence of some imperfection in the lightning rod, is an unfounded one.

Darkness of Thunder Clouds.—Every one has noticed how dense and dark a thunder cloud often is. It sometimes shuts out daylight almost as if it were a solid substance, and the glimmer that penetrates it is generally distinguished by a lurid copper-coloured tint. It appears to me that certain experiments upon the electrification of steam, made by the late Robert Helmholtz and afterwards by myself, go some way towards explaining these peculiarities.

We boil a little water in a tin bottle, and allow the steam to issue from a nozzle at the end of a glass tube which passes through the cork. The shadow of the steam jet is cast upon a white screen by a powerful lime light, and we see that it is of feeble intensity, being almost transparent, and of a

[1] Dr. Lodge has since dealt with Mr. Preece's statement in a letter published in *Nature*, April 6th.

neutral tint, unaccompanied by any trace of decided colour. A small bundle of needles connected by a wire with the electrical machine is placed with the points directed towards the base of the jet, and when the machine is worked there is a discharge of electricity into the steam.

A very striking effect attends this discharge. The shadow of the steam at once becomes intensely dark: it is, however, not quite black, but of a well marked reddish brown tinge. When the electric arc light is used instead of the lime light the resemblance of the colour to that of a thunder cloud is even more striking, and it is difficult to resist the belief that its origin is in both cases due in some manner to electrical action.

The explanation of this phenomenon, which, with some hesitation, I ventured to offer two or three years ago, is that electrification has the effect of increasing the size of the little particles of water contained in the steam jet. When the jet is unelectrified most of these particles are small in relation to a wave length of light, and are quickly evaporated in the surrounding air without ever having become visible: under the influence of electrification they become larger, many of them attaining a diameter of something like a fifty-thousandth part of an inch; they therefore obstruct and scatter the more refrangible constituents of the light, allowing only those of consider able wave length to pass unimpeded. Hence the reddish brown colour.

The way in which this result is brought about, I thought, in the light of Lord Rayleigh's experiments upon water drops, to be as follows:—The immense number of little water particles contained in the jet, some perhaps so small as to consist of only a few molecules, must frequently come into collision with one another. In ordinary circumstances they rebound after colliding, but when electrified the colliding particles coalesce, thus forming larger drops.

This explanation is no doubt open to some objection, and Mr. Aitken, who is an exceedingly high authority on all matters relating to cloudy condensation, has recently stated that he does not agree with it. In fact he has arrived at the exactly opposite conclusion, that the water particles in the electrified jet are of smaller and not of larger size, being at the same time correspondingly increased in number. He thinks that the effect is similar to that observed when a water jet is electrified strongly instead of feebly (as in the experiment of Lord Rayleigh just now referred to), the small particles being prevented by mutual repulsion, consequent upon similar electrification, from coalescing into larger ones as they do under ordinary conditions.

I have said that my own explanation is not altogether satisfactory, but, with all respect, I cannot help thinking that Mr. Aitken's is distinctly less so. Of other explanations that have been put forward, I may mention the one which attributes the condensation to the agency of minute particles of metal thrown off by the electrodes, and the ingenious hypothesis of Robert Helmholtz that it is due to molecular shock resulting from the violent recombination of atoms of oxygen and nitrogen which have been dissociated by electrical action. More work must, however, be done upon the subject

before we can have any certain knowledge as to the cause of this abnormal condensation.[1]

Large Rain Drops.—The experiment of Lord Rayleigh, which I have more than once mentioned, is itself of great interest from a meteorological point of view, accounting as it does for the large size of the rain drops which fall during a thunder shower.

A jet of water two or three feet high is made to issue in a nearly vertical direction from a small nozzle. The shadow of the jet is thrown upon the screen, so that all in the room can see it. At a certain distance above the nozzle the stream of water is found to break up into separate drops, which collide with one another and rebounding after collision become scattered over a considerable space. But when the jet is exposed to the influence of an electrified substance, such as a rubbed stick of sealing wax, the colliding drops no longer rebound but coalesce, and the entire stream of water, both ascending and descending, appears to become nearly coherent, while the character of the sound which it makes as it falls into the pan placed to receive it is entirely changed.

In this case the electrical influence is comparatively feeble. If we increase it by holding the knob of a charged Leyden jar close to the jet, the effect is exactly reversed. The colliding drops no longer coalesce, but are scattered even more widely than when the jet is unelectrified. It is upon this latter observation that Mr. Aitken bases his explanation of the steam jet phenomenon.

Colour of the Sky.—I propose in conclusion to say a few words with regard to a problem which for a long time eluded all attempts at its solution:—What is the cause of the blue colour of the sky? It is now a well ascertained fact that this magnificent tint is almost, if not entirely, due to the scattering of light by the minute particles of dust which even the purest air contains. If there were no dust the sky would be nearly, if not quite, as black by day as it is by night. Yet so tiny are the particles concerned in producing the effect in question that, as Prof. Tyndall has said, there is no doubt that a sky quite as vast as ours and as good in appearance could be formed from a quantity of matter which might be held in the hollow of the hand.

White light, such as issues from the sun, is known to be composed of a mixture of rays of different tints and different wave lengths: the waves of violet and blue light are the shortest, then come in order of length waves of green, yellow, orange, and red light, the last named being the largest. A large proportion of the dust particles in the upper air are of such small dimensions that they are able to reflect and scatter only the shorter waves of

[1] Experiments made since the date of the lecture have convinced me that both my own explanation and that of Mr. Aitken are entirely wrong. It now seems to me highly probable that the phenomenon is in some way due to the electrical dissociation of the atmospheric gases, as suggested by R. Helmholtz. That it is an effect of dust nuclei is perhaps not absolutely disproved, but in the light of the new experiments such an explanation appears to be a barely possible one.

light, those associated with the colours violet and blue: they are not sufficiently large to offer any material obstruction to the longer waves, which accordingly travel onwards unimpeded. The result is that while the whole of the atmosphere illuminated by the sun glows with a bluish light, the sun itself appears to be less blue, or, what is optically the same thing, more yellow, than it would if the air were perfectly dust free. When the sun is observed through a great thickness of air, as is the case when it approaches the horizon, its yellow tint is perfectly distinct and cannot escape notice. The colour of the setting sun is nearly always yellow or orange, or, when the atmospheric particles are unusually large and numerous, it may be even red.

I will take the liberty of showing you a rather old experiment which well illustrates the fact that small particles of matter appear blue by reflected light.

Into this large beaker of water I drop a small quantity of mastic varnish, and stir up the liquid with a glass rod. The mastic is precipitated from the alcoholic solution, and dispersed through the water in the form of exceedingly minute solid particles. When the beaker is illuminated by a strong beam of light directed upwards from beneath it, the liquid assumes a beautiful sky-blue tint. But if we place the magnesium lamp behind the vessel, the colour of the light transmitted is seen to be yellow.

Captain Abney has devised a very pretty experiment for illustrating the effect of sunset colours. The sun is represented by a disc of light about two feet in diameter, which is projected upon the screen by the lantern. In the path of the beam is placed a glass cell containing a solution of hyposulphite of soda, into which a little weak hydrochloric acid has just been dropped. The sun at present appears as at midday, and is sensibly white. The acid, however, causes the gradual precipitation of small particles of sulphur from the solution, and as these increase in number the sun assumes a golden yellow tint, and we may imagine that it is approaching the horizon. Soon the yellow passes into orange, the orange into red, and finally the sun disappears, setting, as you may imagine, in a bank of clouds.

THE DIRECTION OF THE WIND OVER THE BRITISH ISLES, 1876-80.

By FRANCIS CAMPBELL BAYARD, LL.M., F.R.Met.Soc.

(Plates IX.-XI.)

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This paper is as far as possible a reduction, on a uniform plan, of observations of the Direction of the Wind over the British Isles, made twice a day, between the hours of 8 and 10 a.m. and 8 and 10 p.m., at 70 stations during the lustrum 1876-80. These stations comprise nearly, if not quite, all the records accessible; and the date mentioned may be taken as the starting point at which large masses of trustworthy observations of different meteorological elements, made on a uniform plan, with competent observers and trustworthy instruments, first become available for comparison. To get together these records and work them out has occupied most of my leisure hours during the past 4 years, and in the course of it I made a discovery which considerably surprised me. It was as follows: I applied to the Trinity House, London, and to the Commissioners of Irish Lights, Dublin, for copies of the records kept at their respective lighthouses and lightships, and though the greatest courtesy was shown to me by each of these bodies, I found that the whole of the Trinity House Records had been destroyed—they are pulped at the end of every five years—and with respect to those of the Irish Light Commission, the only records which had been preserved are those included in this paper, 8 in number, the originals of which were sent to me. I cannot help thinking that records of such value should be permanently retained.

The 70 records given in Table II. consist of (1) the 9 a.m. and 9 p.m. records of 12 anemometers, and of the hourly readings of the Greenwich anemometer; (2) the 8 a.m. and 8 p.m. observations at the 8 Irish Lightship stations; and (3) the records of 49 Second Order stations, 48 of which are the records of observations at 9 a.m. and 9 p.m., and 1, viz. Durham, where the observations are taken at 10 a.m. and 10 p.m. Such interpolations as were necessary, which in no case exceeded six months in the whole five years, were made by the authority responsible for the respective records, with the exception of those in the records of the Irish lightships, which were made by myself, from comparison with the records from adjacent stations, combined with the wind directions of the *Daily Weather Charts* of the Meteorological Office.

From these records the monthly and yearly percentages of the winds given in the Tables have been obtained. They were made as follows: For every month the winds were tabulated and reduced to 8 directions, with a column for

calms; the 5 months, say 5 Januaries, were added together according to the different winds and the calms, and then each column of addition was divided by the total of all the columns for the percentages. The yearly percentage was obtained by adding together the percentage of every separate wind and dividing by 12. From the percentages thus obtained the wind roses on charts accompanying this paper were drawn to scale. (Plates IX.-XI.)

In considering the charts for the general direction of the wind, a few preliminary remarks seem to be required. With respect to the stations on the sea coast, it will be noticed that, with but few exceptions, the different winds on the side facing the sea have very similar percentages, the result, no doubt, of the winds having come over a considerable stretch of flat surface, for the winds, having nothing to deflect them, would, it would seem, not vary much in direction. The directions of the wind at the stations on the land side of the sea coast and further inland seem to be greatly interfered with by the different hills and valleys, which appear to influence the course of the wind at even our highest stations, viz. Dartmoor, Buxton, and Braemar. There is also a difference between the results at stations where an anemometer is used, and those where eye observations alone are taken, for in the former there is a regularity, probably due partly to the necessary self-recording machinery, and partly to the method of tabulation adopted, viz. taking a mean of the curve between a few minutes before and a few minutes after each hour, which is entirely absent at the stations where eye observations alone are taken. And lastly, at the majority of the stations the calms have a large percentage, a fact which will deserve much further investigation.

The charts accompanying this paper are five in number, one for each of the months of January, April, July, and October, and one for the year. They contain, with but few exceptions, where the records of certain stations are omitted owing to their close proximity to other stations, the whole of the records for those months and the year of the stations mentioned in Table I. I propose to deal with each of these charts separately, and, without complicating the paper with records of pressure and temperature, shall endeavour to give some general idea of the direction of the wind over the British Isles. Should it at any time be thought advisable, it will be a comparatively easy task to construct similar charts for the remaining months from Table II.

January.

On looking at this chart it will be seen that the prevalent wind in the west is the South wind, which becomes a South-west wind when going round the south-east coast of Ireland, changing again into a South wind in the Irish Channel. A similar state of things seems to occur on the south-east coast of England. With these preliminary remarks we shall turn from the sea coast to the country itself, and a glance at the chart at once shows how difficult it is to say what are the prevailing winds in a hilly country. In Scotland the prevailing winds appear to be South-south-west and West,

with a large proportion of East and South-east winds at certain stations, notably at the Butt of Lewis, Lairg, Glenalmond, Glasgow, Annanhill, Eallabus, Mull of Kintyre, St. Abb's Head, Cargen, and Mull of Galloway. In Ireland the prevailing winds appear to be West, South-west, South, and South-east, the Westerly winds at Dublin being specially noticeable. In Wales the prevailing winds appear to be West, South-west, South, South-east, and East, the Easterly winds being noticeable. If we now turn to England it will be noticed that throughout the country the South-west wind is the prevalent one, and combined with this wind there are others varying according to the situation of the station, viz. West and South winds in the north of England, and North-west, West, South-east, East, and North-east in the centre of England and along our east, south-east, and south coasts. In the Isle of Man the winds in the north appear to resemble the winds of the Mull of Galloway, but in the south there does not seem to be very much variety in their percentages. In Jersey the prevailing wind is East, with somewhat large amounts of North-east, South, and South-west winds. I would call attention to the very small variety in the wind percentages at Falmouth.

April.

This chart presents rather a singular appearance, for at Valencia, in the west of Ireland, there is little variety in the wind percentages, but in the south-east of Ireland the percentages of the South-west and North-east winds are the largest and are about equal, but further north along the Irish Channel the South-east winds are decidedly prevalent, changing to South further northward. A similar state of winds appears to prevail on the south-east and east of England, and on the east of Scotland. Turning now to Scotland, we have in the Shetlands winds from the North, North-east, East, South-east, and South, which, with variations in detail, seem to be generally prevalent throughout the country except at the more inland stations, where there is also a large percentage of West and South-west winds. The percentages of the winds on the east coast of Scotland deserve attention, and it would appear that the comparatively large variations in these percentages are not wholly due to the mountainous country on the west and south-west of the stations. In Ireland there is but little difference between the percentages of wind from any quarter, though the prevailing winds on the east and south coasts seem to come more from the South-west and North-east, and at Dublin from the West and East, than from any other quarter. In Wales there is, as far as we can tell from the data employed, a prevailing wind from the East, but this is combined with a Southerly wind at Holyhead, and a Westerly one at Llandudno. In the north of England there are North-east, East, and South-east winds, which, in the south, are gradually joined by winds from the North-west, West, and South-west. In the Isle of Man the winds are North-east, East, and South-east, with a moderate percentage of West in the north of the island, and of North and South in the south. In Jersey the prevailing winds are North-east and South-west, with a moderate percentage of South

and West. The comparatively uniform appearance of the wind percentages at Falmouth is again noticeable.

JULY.

In considering this chart there seems to be a singular variation in the wind percentages in the Irish Channel. In the south of Ireland the winds are North, North-west, and West; in the south-east the winds are North-west, West, and South-west, but as we go up the channel the percentage of South-west wind gradually becomes smaller until we come to the Mull of Kintyre, from which station the percentage gradually increases as we go north along the west coast of Scotland. On the south and east coasts of England and the east coast of Scotland the winds are rather different, for there seems to be at nearly all the stations a fairly large percentage of South-west winds combined with winds from the West and North-west. On looking at the chart without special reference to the sea coast winds just referred to, we shall be struck with its fairly uniform appearance in that the prevailing winds, with but few exceptions, are from North *viâ* West to South all over the British Isles. In Scotland the exceptions are at Sandwick, Isle of May, St. Abb's Head, and Mull of Kintyre, where there is rather a large percentage of South-east wind; at Scourie, Lairg, Tarbetness, Arbroath, Glenalmond, Isle of May, Edinburgh, Airds, Annanhill, and Cargen, where there is a moderate percentage of Easterly wind, and at the Butt of Lewis, Braemar, and Callton-Mor, where there is a large one of North-east wind. The same prevailing winds occur also in the Isle of Man and in Ireland, except that in the latter there is rather a large percentage of East and North-east winds at the east coast Lightship stations. In Wales and England there are the same general features, the only exceptions being the moderate percentage of North-east wind at Hull, Hillington, Uppingham, Leicester, Oscott, Ramsgate, and Hastings. In Jersey the winds are similar to those of the rest of the country.

OCTOBER.

This chart has a very singular appearance, and presents great difficulty. If we consider the winds in the Irish Channel we perceive that, though all the southern stations agree in having only a small percentage of South-east wind, each separate station has its own prevailing wind, which varies from North-west *viâ* West to South. When, however, we come to the Isle of Man and go north by the Mull of Kintyre, we have a large percentage of South-east and South winds combined with winds from other quarters, and as we go still further north along the west coast of Scotland, we find that the prevailing winds are South and West. If we now consider the winds on the south-east and east of England, and the east of Scotland, we find that there is a fairly large percentage of South and South-west winds at most of the stations, these winds being combined with others. If we now turn to the chart and consider it without special reference to the sea coast winds, it would appear that, subject to the very notable exceptions to be mentioned further on, all over the British Isles winds of a Westerly type, North-west to South-west,

TABLE I.—List of Stations.

Station.	N. Lat.		Long.	Height above Sea level.	Kind of Station.
	°	′	° ′	ft.	
North Unst, Shetland Isles	60	50	0 55 W	230	2nd Order.
Sandwick, Orkney Isles	59	2	3 18 W	94	Anemometer.
Butt of Lewis, Outer Hebrides	58	32	6 18 W	80	2nd Order.
Scourie, Sutherland	58	21	5 4 W	26	2nd Order.
Lairg, Sutherland	58	2	4 25 W	458	2nd Order.
Tarbetness, Ross	57	53	3 43 W	175	2nd Order.
Monach, Outer Hebrides	57	33	7 45 W	150	2nd Order.
Buchanness, Aberdeen	57	29	1 45 W	90 ?	2nd Order.
Aberdeen, Aberdeen	57	10	2 6 W	46	Anemometer
Braemar, Aberdeen	57	1	3 25 W	1114	2nd Order.
Airds, Argyll	56	35	5 23 W	15	2nd Order.
Arbroath, Forfar	56	33	2 32 W	71	2nd Order.
Glenalmond, Perth	56	26	3 36 W	529	2nd Order.
Skerryvoir, Hebrides	56	18	7 12 W	150	2nd Order.
Isle of May, Fife	56	10	2 35 W	240	2nd Order.
Callton-Mor, Argyll	56	3	5 44 W	65	2nd Order.
St. Abb's Head, Berwick	55	55	2 9 W	224	2nd Order.
Glasgow, Lanark	55	53	4 18 W	184	Anemometer
Edinburgh, Edinburgh	55	53	3 17 W	162	2nd Order.
Eallabus, Isle of Islay	55	48	6 15 W	71	2nd Order.
Annanhill, Ayr	55	37	4 30 W	165	2nd Order.
Stobo Castle, Peebles	55	36	3 22 W	600	2nd Order.
Alnwick Castle, Northumberland	55	25	1 40 W	178	Anemometer
Wolfelee, Roxburgh	55	24	2 35 W	604	2nd Order.
Mull of Kintyre, Argyll	55	19	5 49 W	800 ?	2nd Order.
Cargen, Dumfries	55	2	2 39 W	85	2nd Order.
Seaham, Durham	54	50	1 19 W	100	2nd Order.
Durham, Durham	54	46	1 35 W	335	2nd Order.
Mull of Galloway, Wigtown	54	38	4 52 W	325	2nd Order.
Point of Ayr, Isle of Man	54	27	4 20 W	31	2nd Order.
Armagh, Armagh	54	21	6 39 W	207	Anemometer
Markree Castle, Sligo	54	11	8 27 W	131	2nd Order.
Calf of Man, Isle of Man	54	5	4 46 W	328	2nd Order.
Stonyhurst College, Lancashire	53	51	2 28 W	361	Anemometer.
Hull, Yorkshire	53	45	0 20 W	14	2nd Order.
Kish Bank, Dublin	53	25	5 56 W	..	Lightship.
Bidston, Cheshire	53	24	3 4 W	200	Anemometer.
Kelstern, Lincoln	53	24	0 7 W	388	2nd Order.
Llandudno, Carnarvon	53	20	3 50 W	89	2nd Order.
Dublin, Dublin	53	20	6 15 W	51	2nd Order.
Holyhead, Anglesea	53	19	4 37 W	12	Anemometer.
Buxton, Derby	53	14	1 54 W	987	2nd Order.
Parsonstown, King's County	53	6	7 55 W	182	2nd Order.
Codling Bank, Wicklow	53	4	5 50 W	..	Lightship.
Cheadle, Stafford	52	58	1 57 W	646	2nd Order.
N. Arklow Bank, Wicklow	52	56	5 48 W	..	Lightship.
Hillington, Norfolk	52	48	0 33 E	89	2nd Order.
S. Arklow Bank, Wicklow	52	44	5 54 W	..	Lightship.
Leicester, Leicester	52	39	1 8 W	237	2nd Order.
Yarmouth, Norfolk	52	36	1 43 E	12	Anemometer.
Uppingham, Rutland	52	35	0 44 W	484	2nd Order.
Oscott, Stafford	52	33	1 51 W	460	2nd Order.
Churchstoke, Montgomery	52	31	3 5 W	548	2nd Order.
Blackwater Bank, Wexford	52	30	6 6 W	..	Lightship.
Lucifer Shoals, Wexford	52	20	6 13 W	..	Lightship.
Coningbeg or Saltees, Wexford	52	8	6 37 W	..	Lightship.
Valencia, Kerry	51	55	10 18 W	23	Anemometer.
Carmarthen, Carmarthen	51	52	4 18 W	188	2nd Order.
Daunt's Rock, Cork	51	45	8 18 W	..	Lightship.
Chigwell Row, Essex	51	37	0 6 E	186	2nd Order.

TABLE I.—List of Stations.—*Continued.*

Station.	N. Lat.	Long.	Height above Sea level.	Kind of Station.
	° ′	° ′		
Greenwich, Kent	51 29	0 0	159	Anemometer.
Kew, Surrey	51 28	0 19 W	34	Anemometer.
Marlborough, Wiltshire	51 25	1 43 W	471	2nd Order.
Strathfield Turgiss, Hampshire	51 20	1 0 W	196	2nd Order.
Ramsgate, Kent	51 20	1 25 E	105	2nd Order.
Folkestone, Kent	51 5	1 10 E	159	2nd Order.
Hastings, Sussex	50 52	0 33 E	172	2nd Order.
Dartmoor, Devon	50 33	3 59 W	1372	2nd Order.
Falmouth, Cornwall	50 9	5 4 W	211	Anemometer.
St. Aubyn's, Jersey	49 11	2 10 W	139	2nd Order.

are more prevalent than those of an Easterly type, North-east to South-east. It would also appear that, as we move from north to south, the Westerly type of wind changes almost imperceptibly to the Easterly type, and that this change goes on throughout the British Isles. In Scotland I wish to call attention to the winds at Scourie, Lairg, Edinburgh, and Annanhill, where the different percentages show great irregularities. The Irish stations call for no particular remarks beyond the general ones already made, except that the percentage of Westerly wind at Dublin appears large. Wales also does not call for much comment, with the exception of pointing out the curious difference in the prevailing winds of two stations so near to one another as Llandudno and Bidston. The winds over England call for no remarks beyond the general ones already mentioned, except that the percentages of the different winds at Falmouth seem to be very uniform. In Jersey the prevailing winds are Easterly and North-easterly, with a moderate percentage of South-west.

The Year.

This chart, though practically a *resumé* of the percentages in the previous charts, combined with the percentages of the remaining months, shows some characteristic features which it is worth while to notice. The percentages of the different winds at Valencia, with the exception of those for East and North-east winds, are tolerably uniform, but as we come into the Irish Channel round the south and south-east of Ireland, we see that the percentage of the South-west winds becomes rather large and likewise that of the West wind. As we go further north we find the percentage of the South wind, and then that for the South-east wind, gradually increase to the detriment of the percentages of the other winds, and then as we go north along the west coast of Scotland we have the South-east wind disappearing gradually and the percentages of South-south-west and West winds increasing. Along the south and south-east coasts of England and the east coast of Scotland a very similar variation of winds, with few exceptions, takes place. On looking at the chart, as a whole, we see that in Scotland the Northerly winds have a larger percentage than in England, Wales, and

TABLE II.—PERCENTAGES OF THE DIRECTION OF THE WIND, 1876–1880.

Direction of Winds.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
NORTH UNST.													
N	13	15	22	17	23	16	16	17	21	21	17	19	18
NE	4	9	10	17	6	13	9	11	3	6	11	7	9
E	4	4	6	11	8	11	11	17	4	5	7	9	8
SE	3	9	7	9	8	12	3	11	7	3	6	10	7
S	28	20	21	23	14	20	14	13	18	29	20	19	20
SW	20	18	12	10	12	11	14	8	15	7	16	12	13
W	20	16	16	7	19	11	25	13	19	18	14	17	16
NW	8	9	6	6	10	6	8	8	12	11	9	7	9
Calm	0	0	0	0	0	0	0	2	1	0	0	0	0
SANDWICK.													
N	4	7	10	10	11	9	6	7	11	13	15	9	9
NE	4	3	6	9	9	3	5	8	3	5	6	5	6
E	4	5	7	13	10	14	8	13	2	1	6	11	8
SE	11	15	18	26	15	23	12	22	15	11	10	8	15
S	22	13	12	10	11	12	8	7	14	16	13	14	13
SW	14	16	9	7	9	8	14	9	11	8	10	16	11
W	18	16	17	6	17	11	24	10	19	21	16	13	15
NW	11	13	12	9	14	11	14	12	17	11	12	13	13
Calm	12	12	9	10	4	9	9	12	8	14	12	11	10
BUTT OF LEWIS.													
N	5	8	14	9	10	7	11	10	12	12	16	14	11
NE	4	4	3	11	16	16	13	16	7	6	9	7	9
E	4	13	22	31	12	20	9	24	8	8	9	12	14
SE	18	15	10	16	8	11	4	11	12	12	11	9	12
S	16	14	13	15	8	12	10	7	10	19	15	21	13
SW	33	25	15	7	17	12	17	13	22	12	19	16	17
W	9	11	15	4	14	11	23	8	16	16	11	12	13
NW	11	9	8	6	11	9	12	10	13	15	10	9	10
Calm	0	1	0	1	4	2	1	1	0	0	0	0	1
SCOURIE.													
N	5	8	9	7	8	9	10	6	8	9	14	15	9
NE	5	6	11	14	15	8	7	9	8	16	20	10	11
E	27	27	26	37	21	29	14	35	18	20	19	25	25
SE	8	9	7	11	5	6	1	6	7	13	10	10	8
S	1	0	3	2	2	1	1	1	2	3	3	1	2
SW	36	35	23	18	27	27	40	21	34	21	23	25	27
W	10	6	8	4	11	14	11	9	11	6	4	4	8
NW	8	9	13	7	11	6	16	13	12	12	7	6	10
Calm	0	0	0	0	0	0	0	0	0	0	0	4	0
LAIRG.													
N	6	7	14	9	6	4	2	1	3	3	5	5	6
NE	0	4	4	6	11	3	2	3	4	3	4	4	4
E	36	37	33	52	33	37	23	46	28	24	31	32	34
SE	3	1	1	4	3	5	4	1	2	6	3	1	3
S	1	1	1	1	1	3	1	1	0	3	0	1	1
SW	3	1	1	3	2	4	2	2	5	3	0	1	2
W	28	32	24	13	28	28	48	22	31	27	29	24	28
NW	1	5	10	1	8	2	4	5	8	9	5	7	5
Calm	22	12	12	11	8	14	14	19	19	22	23	25	17
TARBETNESS.													
N	5	6	11	9	10	5	7	6	9	10	18	8	9
NE	3	3	6	11	17	15	15	13	7	7	5	5	9
E	4	8	13	29	20	21	14	25	6	1	3	6	12
SE	14	12	11	19	8	16	7	17	14	15	13	9	13
S	14	14	7	7	5	8	7	7	8	13	12	11	9
SW	32	23	15	9	10	14	12	10	22	15	22	26	18
W	18	23	19	6	15	12	16	10	18	20	15	23	16
NW	10	10	18	10	15	9	21	12	16	19	12	12	14
Calm	0	1	0	0	0	0	1	0	0	0	0	0	0

TABLE II.—PERCENTAGES OF THE DIRECTION OF THE WIND, 1876–1880—*Continued.*

Direction of Winds.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
MONACH.													
N.	8	8	15	12	15	15	21	15	19	14	21	14	15
NE	4	5	5	11	16	11	6	11	6	8	10	8	8
E	6	11	10	20	7	9	6	17	5	8	9	12	10
SE	8	9	7	11	5	7	1	7	3	6	3	4	6
S	35	23	25	29	21	25	16	20	27	25	22	26	25
SW	16	15	10	6	11	12	12	10	14	10	15	11	12
W	15	20	19	5	10	6	20	7	19	18	15	15	14
NW	8	8	8	4	12	8	13	8	6	10	5	9	8
Calm	0	1	1	2	3	7	5	5	1	1	0	1	2
BUCHANNESS.													
N	11	10	14	12	14	16	23	13	18	16	17	11	15
NE	3	6	6	15	15	8	7	13	5	6	14	5	8
E	5	8	7	12	11	6	6	8	6	7	9	8	8
SE	7	12	7	18	7	10	10	14	7	8	6	7	9
S	19	16	16	17	19	29	19	20	19	22	16	12	19
SW	27	18	19	11	11	14	11	9	13	14	14	20	15
W	15	15	12	5	13	6	7	7	15	11	8	13	11
NW	13	15	19	9	10	9	14	13	16	16	16	24	14
Calm	0	0	0	1	0	2	3	3	1	0	0	0	1
ABERDEEN.													
N	1	2	1	7	12	6	5	6	3	5	8	3	5
NE	1	2	2	8	10	10	7	8	2	0	2	1	4
E	2	5	5	15	5	8	5	7	4	2	4	6	6
SE	9	12	13	20	12	13	9	10	7	13	8	10	11
S	28	19	17	17	19	23	17	15	21	19	16	15	19
SW	18	18	17	5	8	8	10	6	16	12	19	16	13
W	19	18	20	5	9	7	12	11	14	16	15	21	14
NW	10	12	16	13	16	10	19	14	20	20	21	18	16
Calm	12	12	9	10	9	15	16	23	13	13	7	10	12
BRAEMAR.													
N	6	6	11	6	10	3	4	4	4	9	18	10	8
NE	6	14	12	30	20	20	18	26	11	9	15	9	16
E	5	6	10	8	9	13	7	12	6	4	5	5	7
SE	10	4	8	14	8	5	5	8	1	4	3	4	6
S	15	12	1	9	10	10	8	8	7	9	9	5	9
SW	42	44	32	20	26	34	39	28	46	38	31	34	35
W	9	8	14	4	9	7	13	8	14	17	14	20	11
NW	7	6	12	9	8	8	6	6	11	10	5	12	8
Calm	0	0	0	0	0	0	0	0	0	0	0	1	0
IRDS.													
N	5	11	17	13	22	9	13	9	15	20	15	13	14
NE	6	7	15	12	9	3	1	6	4	3	4	6	6
E	26	22	15	28	21	15	15	24	12	19	29	26	21
SE	5	3	4	5	2	5	2	2	2	2	6	5	4
S	18	10	6	11	8	11	6	9	15	14	11	17	11
SW	14	16	6	9	13	20	29	13	15	12	13	13	14
W	15	18	18	16	23	28	26	30	29	18	15	15	21
NW	11	13	18	6	2	9	8	7	8	12	7	5	9
Calm	0	0	1	0	0	0	0	0	0	0	0	0	0
ARBROATH.													
N	9	9	7	16	19	11	11	9	9	11	16	12	12
NE	2	1	3	9	8	9	3	10	5	6	2	6	5
E	6	11	18	23	17	18	12	19	9	5	9	7	13
SE	3	4	5	6	6	9	5	4	4	5	2	3	5
S	12	9	6	15	8	21	15	12	9	12	8	8	11
SW	12	13	7	4	10	5	7	5	12	8	9	11	8
W	31	29	30	14	19	13	30	22	31	21	28	28	25
NW	9	8	12	3	5	7	5	4	6	15	16	10	8
Calm	16	16	12	10	8	7	12	15	15	17	10	15	13

TABLE II.—PERCENTAGES OF THE DIRECTION OF THE WIND, 1876–1880—*Continued.*

Direction of Winds.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
GLENALMOND.													
N	4	5	8	4	8	2	6	2	4	8	14	4	6
NE	6	2	8	15	12	8	8	7	3	6	7	6	7
E	13	7	11	32	21	22	13	29	17	9	7	9	16
SE	4	9	6	10	6	11	5	13	8	5	3	6	7
S	7	6	5	4	5	10	5	7	6	6	6	4	6
SW	27	22	18	14	19	17	18	14	25	18	17	16	19
W	19	22	15	7	14	12	20	17	18	16	16	28	17
NW	9	7	10	6	9	5	11	11	12	13	12	11	9
Calm	11	20	19	8	6	13	14	0	7	19	18	16	13
SKERRYVOIR.													
N	7	8	14	13	19	12	16	13	13	13	18	13	13
NE	4	3	6	14	10	7	7	10	6	10	10	6	8
E	6	5	6	9	9	9	3	11	3	4	6	6	6
SE	13	16	16	26	10	14	8	18	13	17	11	12	15
S	30	18	15	16	13	20	7	11	14	18	13	19	16
SW	14	20	14	9	15	19	18	12	21	13	19	19	16
W	17	20	16	7	13	11	21	13	19	15	14	14	15
NW	9	10	13	6	11	7	17	9	10	10	8	11	10
Calm	0	0	0	0	0	1	3	3	1	0	1	0	1
ISLE OF MAY.													
N	3	3	4	2	1	1	1	1	2	5	6	3	3
NE	5	7	13	14	15	7	7	8	12	12	17	11	10
E	4	9	10	27	14	16	14	26	7	9	8	8	13
SE	9	8	13	23	14	21	12	11	12	8	5	6	12
S	6	6	5	4	5	5	3	5	5	8	4	6	5
SW	9	9	3	7	5	6	6	4	4	10	12	5	7
W	50	47	37	17	30	26	42	27	42	34	31	47	36
NW	9	6	5	1	2	3	3	5	4	8	13	10	5
Calm	5	5	10	5	14	15	12	13	12	6	4	4	9
CALLTON-MOR.													
N	17	10	17	13	10	3	7	4	15	23	30	28	15
NE	9	12	13	18	23	18	16	17	14	12	13	11	15
E	1	5	9	8	4	8	4	6	1	0	2	1	4
SE	29	15	10	34	17	14	8	27	17	24	15	12	18
S	5	4	3	1	3	11	5	3	2	6	1	7	4
SW	21	27	21	16	12	29	25	19	23	15	17	16	20
W	6	7	4	3	14	4	14	6	10	4	7	5	7
NW	12	20	23	7	17	13	21	18	18	16	15	20	17
Calm	0	0	0	0	0	0	0	0	0	0	0	0	0
ST. ABB'S HEAD.													
N	6	8	12	13	14	12	10	9	13	10	20	8	11
NE	5	4	4	11	13	7	8	12	6	7	7	6	8
E	6	7	12	17	9	7	6	9	6	6	6	7	8
SE	14	14	16	26	18	21	12	18	15	14	9	11	16
S	12	8	5	5	6	11	7	6	7	10	9	7	8
SW	28	25	18	12	13	16	14	13	20	20	21	26	19
W	13	22	21	5	14	11	28	17	21	16	13	18	16
NW	16	11	11	9	11	11	13	13	12	15	15	17	13
Calm	0	1	1	2	2	4	2	3	0	2	0	0	1
GLASGOW.													
N	2	2	4	4	4	2	0	2	3	3	7	4	3
NE	8	12	13	27	23	20	12	18	8	13	12	10	15
E	12	13	17	23	15	14	9	22	9	9	6	8	13
SE	7	3	1	5	2	3	2	2	2	6	5	5	4
S	15	9	5	6	8	10	6	5	7	9	11	11	9
SW	20	24	20	11	15	20	23	13	19	17	20	21	18
W	10	14	17	6	18	16	30	16	19	15	10	12	15
NW	2	4	6	2	3	2	5	3	5	3	5	3	3
Calm	24	19	17	16	12	13	13	19	28	25	24	26	20

TABLE II.—Percentages of the Direction of the Wind, 1876–1880—*Continued.*

Direction of Winds.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Edinburgh.													
N	3	6	3	3	3	7	5	3	8	3	6	1	3
NE	4	4	10	13	12	14	11	6	7	7	8	6	9
E	5	10	15	35	32	29	18	35	6	14	11	9	18
SE	11	8	10	11	6	3	3	8	7	8	3	7	7
S	10	4	2	7	4	3	3	4	10	8	4	5	5
SW	12	13	6	3	4	9	6	6	30	8	21	10	11
W	46	48	43	21	30	30	45	32	22	38	35	51	37
NW	7	6	10	6	6	4	8	2	9	12	11	10	8
Calm	2	1	1	1	3	1	1	4	1	2	1	1	1
Eallabus.													
N	8	5	10	11	15	7	13	10	15	13	20	13	12
NE	5	2	5	7	9	6	6	8	2	6	9	6	6
E	9	9	15	25	14	16	5	18	4	5	7	8	11
SE	11	11	6	11	7	5	1	4	7	7	5	5	7
S	24	13	6	12	9	11	8	10	11	20	9	17	12
SW	10	20	12	9	14	18	16	10	15	9	15	11	13
W	10	15	20	5	12	13	18	9	11	8	13	11	12
NW	6	11	13	5	10	10	16	8	6	8	7	6	9
Calm	17	14	13	15	10	14	17	23	29	24	15	23	18
Annanhill.													
N	5	3	8	2	5	5	3	7	5	6	10	3	5
NE	8	8	11	15	11	6	6	6	5	10	11	13	9
E	23	20	19	32	24	22	13	20	15	22	24	21	21
SE	9	6	5	6	7	5	5	8	5	4	5	8	6
S	17	8	6	15	7	15	6	8	9	15	8	9	10
SW	12	17	12	10	14	13	13	15	21	11	15	13	14
W	23	32	33	16	24	27	47	25	35	27	22	23	28
NW	3	6	6	4	8	7	7	11	5	5	5	10	7
Calm	0	0	0	0	0	0	0	0	0	0	0	0	0
Stobo Castle.													
N	5	9	8	6	5	6	2	5	6	5	10	9	6
NE	5	4	11	13	16	6	4	5	7	15	15	9	9
E	7	7	8	21	10	11	8	11	5	7	4	4	9
SE	4	8	7	13	12	11	6	17	7	8	6	5	9
S	12	8	6	11	13	22	13	12	7	11	6	10	11
SW	32	27	16	17	20	25	28	25	27	27	23	26	24
W	20	23	24	6	16	14	24	13	22	15	16	21	18
NW	15	14	20	13	6	5	14	12	19	12	19	15	14
Calm	0	0	0	0	2	0	1	0	0	0	1	1	0
Alnwick Castle.													
N	4	3	8	7	12	8	5	5	7	3	7	4	6
NE	2	1	2	7	8	4	3	5	3	5	6	1	4
E	3	3	7	17	7	5	4	6	1	5	3	5	6
SE	7	10	8	19	9	12	6	7	5	6	5	5	8
S	15	10	8	8	7	9	5	8	8	13	12	9	9
SW	17	15	12	8	10	12	12	9	14	12	13	16	13
W	24	31	26	9	15	17	28	16	23	19	18	33	21
NW	9	11	12	4	6	6	8	7	11	13	19	13	10
Calm	19	16	17	21	26	27	29	37	28	24	17	14	23
Wolfelee.													
N	9	10	8	20	23	15	10	10	12	10	20	13	13
NE	3	7	5	15	11	5	5	12	0	6	7	4	7
E	4	4	6	7	5	7	2	6	3	5	2	4	5
SE	5	3	5	7	6	4	3	6	7	4	3	5	5
S	37	23	19	24	19	32	22	19	21	24	18	19	23
SW	29	37	33	16	17	20	28	28	36	28	35	36	29
W	10	11	13	5	11	12	23	10	14	17	7	13	12
NW	3	5	11	6	8	5	6	9	7	5	8	6	6
Calm	0	0	0	0	0	0	1	0	0	1	0	0	0

TABLE II.—PERCENTAGES OF THE DIRECTION OF THE WIND, 1876–1880—*Continued.*

Direction of Winds.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
MULL OF KINTYRE.													
N	6	7	11	10	17	11	15	10	14	9	15	10	11
NE	6	5	7	16	9	6	5	7	2	13	10	7	8
E	10	12	16	22	16	14	6	21	11	9	13	8	13
SE	23	16	15	26	18	26	13	22	18	17	9	14	18
S	24	18	11	9	11	18	12	7	11	15	13	19	14
SW	10	14	7	4	4	5	6	9	12	8	17	13	9
W	10	16	16	5	6	3	11	7	11	12	10	16	10
NW	11	12	17	7	18	14	30	17	19	17	13	13	16
Calm	0	0	0	1	1	3	2	0	2	0	0	0	1
CARGEN.													
N	7	10	9	7	8	5	9	7	13	9	21	18	10
NE	14	10	13	12	8	9	7	12	15	12	14	10	11
E	17	14	25	37	33	24	17	26	10	19	16	15	21
SE	12	8	5	13	13	19	8	11	8	15	8	12	11
S	21	18	14	18	16	21	21	15	16	13	11	12	17
SW	11	22	14	3	11	9	11	9	16	12	15	14	12
W	9	10	9	7	6	4	17	10	14	12	9	12	10
NW	9	8	11	3	5	9	10	10	8	8	6	7	8
Calm	0	0	0	0	0	0	0	0	0	0	0	0	0
SEAHAM.													
N	2	6	7	10	17	15	12	10	11	4	8	3	9
NE	5	5	5	12	14	4	4	8	5	9	9	4	7
E	7	4	11	15	8	5	2	5	3	5	3	6	6
SE	4	8	6	13	6	7	3	5	4	4	2	5	5
S	23	17	7	10	8	13	8	10	11	17	17	13	13
SW	19	21	19	9	12	18	17	15	21	17	20	26	18
W	19	24	20	8	9	9	17	10	17	16	22	28	17
NW	11	9	13	4	4	4	8	6	8	11	15	10	8
Calm	10	6	12	19	22	25	29	31	20	17	4	5	17
DURHAM.													
N	3	5	7	8	12	7	9	6	10	7	9	2	7
NE	4	7	10	25	22	14	10	19	7	11	8	5	12
E	5	6	8	15	10	7	4	7	2	3	3	5	6
SE	7	5	8	7	5	7	4	5	5	5	2	5	5
S	32	23	13	17	14	19	14	16	21	25	23	23	20
SW	19	21	17	10	15	20	21	16	21	16	19	22	18
W	11	15	16	7	10	8	15	11	12	14	11	14	12
NW	14	14	18	9	10	10	13	12	16	14	22	18	15
Calm	5	4	3	2	2	8	10	8	6	5	3	6	5
MULL OF GALLOWAY.													
N	7	10	9	7	7	8	8	7	11	10	21	10	10
NE	4	3	4	8	8	3	4	8	3	8	6	4	5
E	12	13	25	30	24	20	7	16	9	12	8	11	15
SE	16	6	6	12	4	9	5	9	9	12	8	11	9
S	23	18	9	18	15	24	15	18	21	21	15	13	18
SW	17	23	18	10	11	13	17	13	14	10	17	24	15
W	13	21	16	7	14	10	22	13	17	16	13	15	15
NW	8	6	13	8	16	12	21	14	15	11	12	12	12
Calm	0	0	0	0	1	1	1	2	1	0	0	0	1
POINT OF AYR.													
N	4	6	8	4	7	6	5	3	11	8	13	7	7
NE	6	6	7	14	17	9	5	8	9	7	8	7	9
E	9	9	13	21	14	13	6	15	4	12	11	7	11
SE	17	12	13	25	8	15	7	16	12	14	11	15	14
S	23	14	8	9	8	10	7	8	8	17	11	12	11
SW	10	10	7	6	7	11	8	6	8	7	10	11	8
W	19	26	23	12	16	20	32	21	29	20	22	21	22
NW	11	15	17	6	20	14	27	20	16	12	13	17	16
Calm	1	2	4	3	3	2	3	3	3	3	1	3	2

TABLE II.—PERCENTAGES OF THE DIRECTION OF THE WIND, 1876–1880—*Continued.*

Direction of Winds.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
RMAGH.													
N	1	2	4	6	7	4	2	2	4	3	4	2	3
NE	2	2	6	12	10	6	5	8	2	7	6	4	6
E	7	6	8	12	11	6	2	5	3	2	3	4	6
SE	8	5	4	13	5	4	1	7	4	9	4	5	6
S	30	19	10	14	12	15	8	8	13	17	19	19	15
SW	19	33	24	12	14	14	20	15	26	18	25	29	21
W	6	9	14	5	8	6	9	7	4	5	5	10	7
NW	2	4	5	3	3	4	9	5	6	3	5	3	5
Calm	25	20	25	23	30	41	44	43	38	36	29	24	31
ARKREE CASTLE.													
N	3	5	8	8	12	9	10	8	11	6	9	4	8
NE	3	3	6	10	9	3	4	5	3	7	5	3	5
E	5	3	9	14	13	10	3	8	5	5	4	6	7
SE	23	14	12	19	13	16	5	15	13	18	11	14	14
S	19	17	12	11	7	16	11	16	14	17	11	12	14
SW	13	18	14	9	11	12	16	8	11	8	14	14	12
W	6	8	9	4	7	4	9	5	7	7	7	8	7
NW	6	10	13	6	15	10	19	10	11	9	8	8	10
Calm	22	22	17	19	13	20	23	25	25	23	31	31	23
ALF OF MAN.													
N	6	7	8	13	15	8	16	10	18	12	20	9	12
NE	8	6	9	10	13	10	0	4	3	6	10	7	7
E	13	13	23	22	21	23	9	21	10	18	9	14	16
SE	17	10	7	26	5	5	2	14	8	7	6	9	10
S	21	14	5	12	11	19	15	10	11	19	8	11	13
SW	17	18	15	8	12	21	20	16	18	8	18	16	16
W	11	15	19	5	9	6	24	15	18	15	19	16	14
NW	7	17	14	4	14	8	13	8	14	15	10	18	12
Calm	0	0	0	0	0	0	1	2	0	0	0	0	0
TONYHURST COLLEGE.													
N	3	5	7	6	6	4	2	6	4	4	4	4	4
NE	10	7	14	25	22	16	9	15	5	13	8	7	13
E	9	5	6	12	8	6	3	6	6	4	3	5	6
SE	3	3	2	3	3	6	2	2	2	5	3	4	3
S	11	10	4	8	5	7	7	6	6	10	9	6	7
SW	17	25	22	8	14	21	26	18	20	14	16	15	18
W	11	15	17	8	13	12	23	13	11	10	12	16	14
NW	3	3	5	1	2	1	4	4	7	7	9	5	4
Calm	33	27	23	29	27	27	24	30	39	33	36	38	31
ULL.													
N	4	3	7	4	5	2	6	2	3	4	14	3	5
NE	8	8	11	20	30	18	10	15	7	11	7	7	12
E	7	5	12	12	9	12	7	7	3	7	5	4	8
SE	7	8	8	16	7	8	5	6	5	5	4	7	7
S	6	4	4	5	5	6	6	9	7	4	6	6	6
SW	30	32	20	15	12	19	15	20	16	22	19	25	20
W	15	21	15	8	14	17	24	20	18	14	12	23	17
NW	14	13	16	11	9	9	22	10	17	13	16	11	13
Calm	9	6	7	9	9	9	5	11	24	20	17	14	12
ISH BANK.													
N	7	8	13	6	12	8	17	10	13	13	16	10	11
NE	3	3	5	12	16	10	6	8	4	8	5	3	7
E	5	4	10	12	11	7	3	9	6	10	8	4	7
SE	8	5	7	12	8	4	3	6	4	5	5	4	6
S	20	17	12	20	12	16	13	17	15	11	13	15	15
SW	29	21	12	15	14	22	13	14	17	18	19	20	18
W	10	18	15	7	8	10	14	11	13	12	11	17	12
NW	17	23	21	11	14	13	26	19	24	19	21	25	20
Calm	1	1	5	5	5	10	5	6	4	4	2	2	4

TABLE II.—Percentages of the Direction of the Wind, 1876–1880—Continued.

Direction of Winds.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Bidston.													
N	6	5	6	4	7	5	3	4	5	6	11	4	6
NE	9	4	10	17	17	6	3	8	6	13	12	7	9
E	14	10	15	21	16	14	7	17	10	11	6	11	13
SE	27	18	13	20	7	16	7	16	14	26	17	22	17
S	14	11	3	8	5	6	8	6	9	9	12	9	8
SW	11	22	21	9	12	16	17	14	18	13	13	18	15
W	13	23	22	14	24	24	38	27	24	15	16	21	22
NW	6	7	10	7	12	13	17	8	13	7	13	8	10
Calm	0	0	0	0	0	0	0	0	1	0	0	0	0
Kelstern.													
N	8	7	9	5	14	8	6	3	7	7	15	8	8
NE	8	5	10	18	20	10	8	17	10	13	8	4	11
E	10	4	13	19	12	14	4	13	6	7	3	7	9
SE	8	7	6	14	9	9	7	9	6	8	5	7	8
S	11	14	7	12	9	12	7	9	8	12	10	13	10
SW	26	26	18	14	15	23	24	20	21	21	25	26	22
W	12	19	20	7	11	14	23	18	21	14	12	21	16
NW	14	15	15	8	7	6	16	8	15	13	20	12	12
Calm	3	3	2	3	3	4	5	3	6	5	2	2	4
Llandudno.													
N	4	9	9	9	11	14	11	12	13	4	11	9	10
NE	5	4	7	7	8	6	3	5	6	3	6	4	5
E	14	7	18	27	33	17	8	15	8	18	13	8	15
SE	10	8	7	12	4	3	2	10	5	7	5	8	7
S	15	10	5	10	5	8	5	6	5	11	14	10	9
SW	16	20	8	8	7	10	9	12	11	16	12	16	12
W	31	38	37	21	24	33	47	32	41	33	31	38	34
NW	5	4	9	6	8	9	15	8	11	8	8	7	8
Calm	0	0	0	0	0	0	0	0	0	0	0	0	0
Dublin.													
N	3	4	7	7	11	4	6	4	7	5	7	2	5
NE	2	2	4	14	13	7	4	8	3	8	5	0	6
E	8	6	13	16	19	15	9	13	7	10	5	5	11
SE	14	9	10	16	6	10	5	9	9	6	5	9	9
S	12	9	3	8	5	10	5	8	5	14	8	8	8
SW	21	15	9	8	10	14	9	11	14	12	18	17	13
W	24	37	32	18	20	24	36	22	28	24	30	40	28
NW	7	11	14	8	11	10	19	14	18	12	15	10	12
Calm	9	7	8	5	5	6	7	11	9	9	7	9	8
Holyhead.													
N	4	5	8	4	12	7	9	6	10	7	12	4	7
NE	6	5	9	14	15	7	4	7	6	9	11	6	8
E	14	7	16	19	16	11	4	13	7	12	9	8	12
SE	6	6	3	8	1	2	1	2	4	7	5	11	5
S	29	22	10	21	12	25	15	18	19	17	17	19	18
SW	14	24	20	10	17	22	28	21	19	14	16	17	18
W	9	16	12	7	8	8	15	10	13	14	12	15	12
NW	7	7	10	7	11	7	14	13	11	9	11	12	10
Calm	11	8	12	10	8	11	10	10	11	11	7	8	10
Buxton.													
N	7	6	8	5	7	3	5	4	6	4	7	7	6
NE	8	6	8	7	14	6	4	3	7	7	12	4	7
E	13	7	17	20	22	13	7	15	6	12	9	7	12
SE	7	7	4	18	7	14	6	11	5	11	7	7	9
S	2	1	1	5	3	2	1	4	2	2	2	2	2
SW	11	7	10	12	9	15	13	12	16	16	11	13	12
W	24	37	23	18	15	18	18	21	18	17	20	26	21
NW	20	23	25	12	21	27	44	25	32	25	26	28	26
Calm	8	6	4	3	2	2	2	5	8	6	6	6	5

TABLE II.—PERCENTAGES OF THE DIRECTION OF THE WIND, 1876–1880—*Continued.*

Direction of Winds.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
RSONSTOWN.													
N	2	3	4	6	10	7	7	6	6	9	6	4	6
NE	3	2	4	8	8	5	4	6	2	7	5	2	4
E	5	2	4	11	7	4	1	4	5	5	4	4	5
SE	25	15	14	23	15	12	7	17	11	16	14	15	15
S	17	16	9	10	7	13	8	9	12	12	12	18	12
SW	16	24	20	10	13	20	21	19	18	16	19	18	18
W	8	18	21	11	14	11	19	13	11	10	10	14	13
NW	4	8	11	9	16	12	19	12	14	6	11	5	11
Calm	20	12	13	12	10	16	14	14	21	19	19	20	16
DLING BANK.													
N	7	10	12	9	13	11	12	11	11	10	14	10	11
NE	5	4	6	12	18	8	8	12	10	10	8	4	9
E	9	4	10	15	14	7	2	7	6	11	9	6	8
SE	8	5	9	10	4	2	4	3	4	5	5	4	5
S	15	9	5	12	8	9	5	8	8	12	9	10	9
SW	30	32	22	20	20	34	23	26	29	18	19	23	25
W	14	20	17	10	9	10	15	12	15	17	18	21	15
NW	10	14	14	6	8	6	20	12	15	14	17	19	13
Calm	2	2	5	6	6	13	11	9	2	3	1	3	5
HEADLE.													
N	10	10	9	7	9	10	6	6	11	7	17	10	9
NE	10	5	9	18	17	7	3	7	8	12	12	6	10
E	12	7	19	14	16	15	9	20	7	15	6	7	12
SE	8	6	7	13	6	10	7	7	6	10	4	8	8
S	13	13	6	13	7	14	8	9	7	11	12	9	10
SW	9	28	16	7	11	16	16	16	16	14	17	18	15
W	9	11	11	8	9	9	15	12	16	10	8	12	11
NW	9	14	16	9	13	14	30	13	18	13	17	16	15
Calm	20	6	7	11	12	5	6	10	11	8	7	14	10
. ARKLOW BANK.													
N	7	10	10	7	13	9	15	10	11	11	15	9	11
NE	6	5	7	15	23	10	10	16	9	9	8	3	10
E	10	5	10	14	10	8	3	8	6	12	9	8	9
SE	7	5	9	11	6	4	2	6	4	6	6	5	6
S	16	12	8	16	7	13	6	10	8	10	7	11	10
SW	29	29	18	16	17	29	28	21	23	21	19	23	23
W	13	24	22	12	13	13	18	14	22	18	20	22	17
NW	8	9	13	5	8	8	14	9	14	10	15	17	11
Calm	4	1	3	4	3	6	4	6	3	3	1	2	3
ILLINGTON.													
N	4	4	8	3	7	3	6	2	7	7	8	5	5
NE	12	8	13	22	28	15	11	18	9	10	12	6	14
E	8	2	11	9	11	10	3	6	8	11	5	5	7
SE	15	10	11	21	14	15	8	14	8	9	7	14	12
S	9	10	4	8	3	6	5	7	9	7	7	7	7
SW	25	34	22	19	19	31	31	23	19	26	29	34	26
W	9	13	12	8	8	13	13	13	15	12	12	9	12
NW	13	17	18	9	9	6	22	15	19	15	19	19	15
Calm	5	2	1	1	1	1	1	2	6	3	1	1	2
S. ARKLOW BANK.													
N	8	9	10	6	11	7	10	11	13	12	19	14	11
NE	7	6	8	19	27	15	14	16	10	10	9	8	12
E	9	4	9	10	12	4	2	8	5	13	9	6	8
SE	8	6	8	11	3	4	4	7	5	10	6	6	6
S	17	13	10	16	7	16	7	9	8	13	7	10	11
SW	30	27	16	18	17	25	24	19	24	17	21	21	22
W	11	22	21	8	11	12	18	13	20	15	16	19	15
NW	8	11	15	7	8	9	15	11	10	9	13	14	11
Calm	2	2	3	5	4	8	6	6	5	1	0	2	4

TABLE II.—PERCENTAGES OF THE DIRECTION OF THE WIND, 1876–1880—*Continued.*

Direction of Winds.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
LEICESTER.													
N	6	5	8	5	5	6	3	5	7	4	12	3	6
NE	14	8	18	28	35	17	11	16	11	15	15	9	16
E	6	4	5	9	5	6	2	4	3	9	3	4	5
SE	6	5	6	8	4	6	4	5	5	7	4	6	6
S	14	9	4	9	7	11	7	5	6	7	7	8	8
SW	27	39	28	22	24	31	30	28	29	27	29	41	29
W	7	12	15	8	7	11	21	14	15	12	7	11	12
NW	7	8	9	3	6	5	14	7	10	6	15	7	8
Calm	13	10	7	8	7	7	8	16	14	13	8	11	10
YARMOUTH.													
N	1	4	7	6	13	6	4	6	4	5	7	2	5
NE	9	7	10	16	23	12	5	12	4	5	8	4	10
E	16	4	15	17	11	12	4	10	10	15	10	8	11
SE	6	5	6	14	6	6	9	10	4	6	4	7	7
S	11	13	6	14	11	17	10	10	9	10	10	10	11
SW	16	19	12	8	12	14	17	15	16	17	21	18	15
W	18	29	25	10	10	13	21	15	20	20	22	32	20
NW	12	8	13	5	6	5	13	9	14	9	14	10	10
Calm	11	11	6	10	8	15	17	13	19	13	4	9	11
UPPINGHAM.													
N	7	9	12	6	8	6	7	8	9	8	18	9	9
NE	9	4	8	21	29	14	6	12	4	12	8	7	11
E	8	2	11	10	7	7	4	4	4	6	2	2	5
SE	7	5	6	10	5	6	3	5	5	4	5	8	6
S	12	10	7	14	9	10	9	12	11	11	11	9	11
SW	25	30	18	13	14	23	19	21	13	18	20	25	20
W	9	18	17	10	10	16	28	8	12	18	13	21	15
NW	14	14	14	6	9	11	15	15	19	8	16	12	12
Calm	9	8	7	10	9	7	9	15	23	15	7	7	11
OSCOTT.													
N	10	10	10	10	14	10	6	6	11	9	17	8	10
NE	14	6	15	23	25	15	10	21	11	17	11	9	15
E	9	6	11	15	8	8	5	8	7	9	2	5	8
SE	6	5	2	7	4	5	2	5	6	5	5	6	5
S	24	22	10	15	12	18	13	12	14	16	17	15	15
SW	15	23	20	14	15	23	27	22	21	17	18	25	20
W	10	17	14	7	8	8	15	11	10	10	12	15	11
NW	8	7	15	5	10	9	20	11	15	9	15	10	11
Calm	4	4	3	4	4	4	2	4	5	8	3	7	5
CHURCHSTOKE.													
N	3	5	7	9	15	3	5	5	4	4	13	10	7
NE	9	4	8	11	12	7	5	12	5	11	10	7	8
E	12	6	12	16	10	7	3	10	5	10	4	7	9
SE	12	6	5	15	9	13	4	10	6	17	8	11	9
S	13	7	7	8	8	11	6	6	5	8	7	4	8
SW	14	29	19	11	15	20	23	21	20	15	13	17	18
W	16	17	18	10	10	12	24	14	21	12	22	19	16
NW	8	16	11	11	13	16	18	7	16	9	15	18	13
Calm	13	10	13	9	8	11	12	15	18	14	8	7	12
BLACKWATER BANK.													
N	7	9	11	6	10	7	10	7	13	8	17	11	10
NE	6	4	8	17	26	13	12	18	7	12	9	5	11
E	9	4	8	12	14	5	3	8	6	13	9	5	8
SE	10	6	10	10	5	5	3	7	5	6	5	7	7
S	14	10	8	15	7	13	6	9	7	13	7	13	10
SW	28	28	16	19	16	27	24	17	22	16	18	21	21
W	15	22	21	10	12	15	20	17	22	18	18	18	17
NW	10	14	16	8	8	8	19	12	14	12	16	19	13
Calm	1	3	2	3	2	7	3	6	4	2	1	1	3

TABLE II.—PERCENTAGES OF THE DIRECTION OF THE WIND, 1876–1880—*Continued.*

Direction of Winds.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
LUCIFER SHOALS.													
N	7	11	8	3	7	4	6	5	11	9	16	12	8
NE	8	4	9	16	23	15	11	15	7	12	8	6	11
E	8	5	11	16	17	9	7	14	8	13	9	4	10
SE	9	5	8	9	7	3	2	5	3	5	5	8	6
S	14	8	7	11	6	8	3	7	7	10	7	9	8
SW	30	22	14	19	15	29	19	18	20	21	16	19	20
W	16	31	28	15	16	20	30	20	28	20	25	26	23
NW	7	13	14	9	8	5	17	11	14	10	14	15	12
Calm	1	1	1	2	1	7	5	5	2	0	0	1	2
CONINGBEG OR SALTEES.													
N	6	10	12	6	9	5	7	8	13	11	13	13	9
NE	9	5	6	14	14	6	5	7	8	13	16	7	9
E	9	3	11	13	19	13	10	18	8	12	8	7	11
SE	13	8	12	15	10	6	3	7	6	8	6	6	8
S	19	10	6	16	8	11	4	11	9	14	8	10	11
SW	22	26	16	13	13	25	22	14	17	15	19	21	19
W	13	24	22	12	15	21	27	19	24	15	18	20	19
NW	8	12	14	9	9	8	18	12	14	11	11	16	12
Calm	1	2	1	2	3	5	4	4	1	1	1	0	2
VALENCIA.													
N	2	8	9	10	18	13	15	7	13	8	9	7	10
NE	6	4	8	11	11	4	3	5	5	13	12	8	7
E	11	3	6	11	8	4	2	6	4	7	6	4	6
SE	17	11	12	15	11	7	5	15	12	10	11	12	12
S	20	14	7	10	10	18	12	10	11	14	13	15	13
SW	13	18	11	10	8	14	11	9	15	8	12	11	12
W	11	18	17	9	14	13	19	16	11	13	12	15	14
NW	5	12	13	9	8	13	22	13	13	8	10	10	11
Calm	15	12	17	15	12	14	11	19	16	19	15	18	15
CARMARTHEN.													
N	10	9	16	8	19	10	9	8	8	6	16	7	10
NE	6	3	3	5	7	5	3	3	2	6	3	3	4
E	17	10	21	22	21	10	2	21	8	23	14	12	15
SE	8	7	4	13	4	7	2	5	5	3	3	5	6
S	7	7	3	9	8	10	4	7	3	5	3	5	6
SW	13	23	15	11	12	21	21	16	19	14	18	14	16
W	9	13	12	11	11	13	20	18	16	15	9	15	14
NW	5	7	9	4	6	3	10	5	7	3	6	5	6
Calm	25	21	17	17	12	21	29	17	32	25	28	34	23
DAUNT'S ROCK.													
N	9	3	16	13	15	15	17	14	17	15	15	21	15
NE	11	8	10	10	13	6	7	6	5	13	15	9	9
E	7	4	10	12	15	8	8	11	7	11	9	4	9
SE	12	2	10	12	9	5	1	8	6	6	4	4	7
S	16	11	6	13	9	8	4	9	9	16	10	11	10
SW	18	17	10	16	12	22	12	13	13	13	14	15	14
W	17	29	17	16	16	22	28	23	26	15	20	20	21
NW	9	15	20	7	9	9	20	13	15	9	12	15	13
Calm	1	1	1	1	2	5	3	3	2	2	1	1	2
CHIGWELL ROW.													
N	12	12	9	9	13	7	7	7	13	12	16	9	10
NE	14	7	14	12	21	8	5	13	7	15	9	8	11
E	16	5	14	17	15	17	7	11	9	11	9	11	12
SE	10	5	8	13	9	7	8	6	7	5	6	7	8
S	11	15	7	13	11	13	9	16	8	11	7	8	11
SW	13	25	18	17	15	21	29	24	21	15	20	12	19
W	9	16	16	10	7	14	19	11	13	10	10	19	13
NW	9	11	12	4	5	8	9	4	10	8	14	13	9
Calm	5	4	2	5	4	5	7	8	12	13	9	13	7

TABLE II.—Percentages of the Direction of the Wind, 1876–1880—*Continued.*

Direction of Winds.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Greenwich.													
N	9	11	12	11	17	9	10	9	9	9	19	10	11
NE	14	6	13	17	21	10	7	13	9	16	11	7	12
E	12	5	13	16	12	12	7	11	7	10	4	7	10
SE	8	6	5	8	5	5	4	4	6	7	6	7	6
S	15	12	6	12	8	13	9	10	9	11	13	12	11
SW	22	35	24	21	22	34	34	32	31	26	26	33	28
W	12	19	18	11	9	11	22	15	18	13	12	15	15
NW	4	5	7	3	4	4	7	5	7	5	8	6	5
Calm	4	1	2	1	2	2	0	1	4	3	1	3	2
Kew.													
N	5	7	6	8	11	6	3	6	6	5	14	6	7
NE	14	2	14	18	20	8	4	12	3	13	9	6	10
E	8	5	11	14	11	9	6	8	3	6	4	6	7
SE	2	4	3	4	2	4	3	1	3	2	3	3	3
S	12	11	6	12	7	12	7	10	7	10	11	10	10
SW	17	28	22	16	17	25	28	25	19	18	17	20	21
W	8	14	15	8	8	9	19	10	15	8	7	12	11
NW	4	5	7	3	5	4	6	5	3	3	8	6	5
Calm	30	24	16	17	19	23	24	23	41	35	27	31	26
Marlborough.													
N	3	5	8	6	15	4	3	4	6	5	9	6	6
NE	9	3	7	11	14	10	4	7	4	11	5	3	7
E	10	2	11	14	9	7	3	8	2	8	1	4	7
SE	1	4	2	3	1	3	1	1	2	1	3	2	2
S	10	6	5	7	5	10	5	5	4	6	4	7	6
SW	10	23	12	12	14	19	22	20	13	19	15	11	16
W	15	19	22	12	9	9	21	11	11	8	15	20	14
NW	4	7	7	2	4	4	5	3	7	3	6	6	5
Calm	38	31	26	33	29	34	36	41	51	39	42	41	37
Strathfield T.													
N	8	10	11	7	8	4	4	3	6	6	16	6	7
NE	17	5	13	21	22	8	2	16	4	14	15	8	12
E	9	2	9	9	10	7	4	6	5	8	2	3	6
SE	12	11	6	8	6	7	6	8	7	6	5	9	8
S	7	8	4	8	6	10	7	6	6	6	7	6	7
SW	13	19	19	16	19	34	33	30	24	19	13	21	22
W	10	20	17	14	12	16	26	16	19	11	16	17	16
NW	9	12	15	13	10	6	11	11	15	12	15	16	12
Calm	15	13	6	4	7	8	7	4	14	18	11	14	10
Ramsgate.													
N	6	6	5	8	9	5	4	5	5	5	8	2	6
NE	18	12	14	24	24	18	10	21	9	14	6	7	15
E	7	3	13	11	14	8	9	6	2	8	4	6	7
SE	1	2	2	4	4	6	3	4	2	3	4	3	3
S	13	13	5	10	4	9	11	7	15	13	13	11	10
SW	16	32	26	22	24	30	33	35	23	19	23	30	26
W	13	15	17	8	5	8	16	6	11	15	17	18	13
NW	6	8	11	4	5	4	7	4	13	6	14	7	7
Calm	20	9	7	9	11	12	7	12	20	17	11	16	13
Folkestone.													
N	15	14	18	10	19	12	7	13	14	13	21	13	14
NE	7	5	16	16	23	10	5	11	4	12	5	7	10
E	21	7	10	21	9	16	11	11	9	15	5	7	12
SE	5	2	2	5	4	3	2	3	3	4	5	7	4
S	17	17	8	14	9	17	10	12	14	12	18	16	13
SW	8	24	16	15	18	23	31	23	15	14	9	20	18
W	13	19	20	8	10	11	21	19	15	18	17	18	16
NW	10	8	8	5	5	4	8	6	12	6	14	7	8
Calm	4	4	2	6	3	4	5	2	14	6	6	5	5

TABLE II.—PERCENTAGES OF THE DIRECTION OF THE WIND, 1876–1880—*Continued.*

Direction of Winds.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
HASTINGS.													
N	11	12	14	7	13	9	7	11	12	12	19	11	11
NE	24	10	22	29	31	18	11	20	18	24	16	15	20
E	9	4	7	10	7	8	5	4	6	9	3	4	6
SE	7	3	2	6	4	5	3	2	4	3	3	4	4
S	11	16	7	12	10	11	8	10	8	12	12	14	11
SW	16	23	18	16	17	27	34	29	17	14	16	18	20
W	11	21	19	11	11	15	24	16	21	13	18	19	17
NW	8	6	8	5	4	3	5	7	9	9	10	13	7
Calm	3	5	3	4	3	4	3	1	5	4	3	2	4
DARTMOOR.													
N	5	8	9	5	8	2	7	2	5	3	11	7	6
NE	11	8	9	13	14	7	4	8	6	7	12	9	9
E	18	4	16	15	22	9	5	18	11	23	11	8	13
SE	8	6	4	10	8	5	2	3	6	8	4	6	6
S	9	7	5	8	6	9	4	7	7	6	7	6	7
SW	15	20	7	16	13	16	15	21	10	14	15	19	15
W	8	21	16	13	12	22	28	18	20	12	13	14	16
NW	10	12	21	11	13	11	20	14	24	14	15	13	15
Calm	16	14	13	9	4	19	15	9	11	13	12	18	13
FALMOUTH.													
N	11	10	11	11	13	8	5	6	11	9	18	11	10
NE	8	3	5	10	8	3	3	3	2	10	8	4	6
E	11	3	14	11	17	8	5	10	7	12	4	3	9
SE	13	6	6	9	6	7	5	9	6	9	6	8	7
S	15	14	7	13	10	15	7	9	11	13	9	14	11
SW	16	22	12	13	12	18	17	18	12	10	17	16	15
W	11	23	19	16	11	18	27	19	18	16	15	17	18
NW	9	12	18	11	19	15	22	16	21	12	15	16	16
Calm	6	7	8	6	4	8	9	10	12	9	8	11	8
ST. AUBYN'S.													
N	5	6	11	4	8	8	5	4	5	6	10	9	7
NE	14	12	14	20	34	12	9	15	16	15	19	10	16
E	21	5	15	9	8	6	4	7	10	20	9	7	10
SE	9	5	5	8	5	7	2	6	8	10	5	8	6
S	12	13	6	10	5	9	6	6	6	9	8	13	9
SW	16	26	12	19	13	17	26	25	16	12	21	18	18
W	7	17	16	12	12	19	29	20	16	10	11	14	15
NW	8	8	13	9	9	7	8	7	13	8	8	10	9
Calm	8	8	8	9	6	15	11	10	10	10	9	11	10

reland, and that this percentage is greater at the sea-coast stations than at he inland ones. Easterly winds, that is winds from North-east to South-ast, have a moderate percentage throughout the British Isles; and finally he Westerly winds, that is winds from North-west to South-west, have the rgest percentage of all winds, though this does not much exceed the per-ntage of the Easterly winds except at a few favoured places.

In conclusion, I may add that, though the period dealt with in this paper a short one, I cannot help thinking that the question of the direction of he wind and its influence on our climate and health will become one of the ost important problems of meteorological science to be investigated in the ear future, a view which is confirmed by the inspection of the charts and he facts which I have enumerated above, and I shall feel amply repaid if I n induce anyone to go on with this investigation. This paper has only

dealt with the direction of the wind, but there is another question connected with this branch of our science, and that is the force of the wind, but for the present this cannot be undertaken.

I have to express my gratitude to all those who have so kindly aided me—to the Corporation of the Trinity House, the Commissioners of Northern Lights, the Commissioners of Irish Lights, the Meteorological Council, Mr. Gaster, and Mr. Marriott; and last, but by no means least, my most cordial thanks are due to Dr. Buchan, from whose paper, "The Mean Pressure of the Atmosphere and the Prevailing Winds over the Globe for the months and for the year" (*Transactions of the Royal Society of Edinburgh*, Vol. XXV. p. 575), I have derived considerable aid, and who has besides in other ways most willingly helped me.

DISCUSSION.

The President (Dr. Williams) said that the principal feature in Mr. Bayard's results was that on the western coasts of the British Isles there was great prevalence of South-westerly winds, while on the eastern coasts Easterly currents of air chiefly prevailed. Inland stations appeared to be influenced to some extent by their proximity to mountain ranges, which gave rise to great diversion of winds. He had tried some years ago to ascertain if there was any connection between prevailing winds and mortality, but the observations at his disposal were so few that he was unable to discover any relation between the two. Doubtless, in time, a close connection between the prevalence of certain winds and the spread of epidemics would be traced, but large numbers of observations were required for that purpose,

Rev. W. Clement Ley said that the paper was exceptionally valuable as being a purely observational compilation, thus affording good foundation for the consideration of some dynamical problems relating to winds. In the *Journal* of the Scottish Meteorological Society, July 1873, and in the *Quarterly Journal* of the Royal Meteorological Society, October 1877, he (Mr. Ley) had pointed out that the mean "angle of deviation" was least, and therefore the mean angle of inclination to the lower isobars greatest, in the front of an advancing cyclone, *i.e.* in a general way in the South and South-east winds of systems of depression, if we base our conclusions on the cyclonic winds of Europe. If we proceed in a northerly course over the rugged western coasts of the British Isles and of Scandinavia, we find an increasing cyclonic tendency in the winds, while if we proceed southward, we encounter winds which are relatively anticyclonic in character. These facts put together, and related to the further fact that the frictional resistance to wind produced by a hilly coast line increases the angle of inclination, probably account for the greater seaward tendency of winds on our western as compared with those on our eastern coasts. It was possibly this tendency, together with the difference in the topography of the country surrounding each place, that produced the discordance in the wind records for such adjacent stations as Bidston and Llandudno. Mr. Ley then read a quotation from Carl Kassner's recently published paper, *Ueber kreisähnliche Cyklonen*, in which some conclusions as to the differences between sea, coast, and inland winds of the cyclonic type were given.

Mr. M. Jackson said that the Harbour Master at Ramsgate had supplied him with the observations of wind direction made there during the years 1871-80 inclusive. The directions were not instrumental records, but merely eye observations. He had compared these statistics with the results for the nearest places given in Mr. Bayard's paper, and had found that there was a remarkable agreement. The winds of greatest frequency during the ten years were West, which blew on 366 days, or an average of 37 days each year; East, 344 days, or 34 days each year; and South-west, 300 days, or 30 days each year. There was a popular idea that Easterly winds were those of greatest frequency, but so far as Ramsgate was concerned, Westerly and South-westerly winds predominated.

Mr. C. HARDING inquired whether the percentages for each separate year were given in the paper or only the average of the five years dealt with. Five years was too short a period on which to base reliable averages, but if the summaries for each year were given, some very useful data would be made available for future reference, and the value of the paper greatly enhanced. The five years covered by Mr. Bayard's results were years of widely different character, including as they did 1879, one of the wettest years on record, as well as one or two exceptionally severe winters. He would like to know whether the Liverpool observations were those from the old Liverpool Observatory or from Bidston, as the observatory at Liverpool was not well situated for determining the true direction of the wind, and any observations from thence were practically of no value, the wind being so greatly modified by the trend of the Mersey valley.

Dr. BUCHAN said that some very valuable information would doubtless be obtained if the atmospheric pressure, temperature, and humidity for these five years were worked up and discussed in conjunction with the average direction of wind contained in Mr. Bayard's paper. It was well known that the general direction of the wind was West or South-west on the southern coast of Ireland and south-western coasts of England, but when these air currents reached the St. George's Channel they became deflected into Southerly winds, the channel seeming to form a trough into which the winds from the Atlantic were drawn northwards, so that off the east coast of Ireland Southerly winds prevailed. It was remarkable that the only part of Ireland where the rainfall was comparatively small was north of Dublin. In the case of an air current flowing up a narrow channel, such as the St. George's, the central part of the current moved more rapidly than the sides owing to the land offering greater resistance to the current's progress than the sea, the result of this condition of things being that the wind had a tendency to be drawn off the shore no matter in what direction the coast faced. Valleys also played an important part in determining the direction of the prevailing wind, the tendency of the air current being to flow parallel with the lie of the valley. The valleys of Scotland mostly ran in a south-west to north-east direction, and the prevalent winds were from one or other of these points. In calm weather, such as is experienced under anti-cyclonic conditions, the night temperature of valleys falls to a very low point and a rush of cold air down the surrounding slopes is set up. As regards the influence of the direction of wind upon mortality, referred to by the President it was noticeable that usually the spring time of the year was marked by an undue prevalence of diseases having their seat in the skin and nervous system, a condition of things which appeared to be due to the dryness of the atmosphere at this period of the year, the prevailing Easterly wind being favourable to great atmospheric dryness.

Mr. R. INWARDS remarked that in dealing with the question of the influence of wind upon mortality, the weather at the time when persons fell ill should be considered rather than the conditions prevailing when death occurred.

Dr. EWART remarked that the annual recurrence of increased prevalence of pneumonia during the months of March and April was a fact with which physicians were very familiar, and in the present year this form of disease had been exceedingly common. Possibly the dryness of the season had an irritating effect upon the air passages; and besides this the fine weather recently experienced had doubtless tempted people to go about with less clothing than usual and chills had resulted. The effect of wind direction on catarrhal affections was often most marked, and the case of a patient recently under his care afforded a remarkable instance of this effect. For several weeks during the prevalence of Easterly winds this person had been a great sufferer, and in spite of all the remedies used was very little benefited, but immediately the wind changed from East to South-west all symptoms of catarrh disappeared and the patient was able to leave his bed, practically speaking, recovered.

Mr. SYMONS said that it was so very long ago since the observatory at Liverpool Docks was given up that he did not think it likely that the observations in Mr. Bayard's paper were from the old anemometer, which, besides its unfavourable situation, was also open to objection on account of its unsatisfactory condition. The new observatory at Bidston, however, was as well situated as it was possible to imagine, and the instruments were kept in good order. The direction of wind appeared to very largely depend upon topographical features,

and ranges of hills doubtless played an important part in influencing the direction of wind, as the cold summits would cause a considerable amount of condensation, and volumes of cold air would flow down the hill sides and exercise a disturbing effect upon the air currents in the valleys.

Mr. BAYARD, in reply, said that the whole of the wind tabulations for each place and each year were contained in a book which he proposed placing in the Library of the Society. The results for each year could be printed if the Society saw fit to do so. The observations for Liverpool were from Bidston Observatory.

Notes about Two Photographs of Lightning taken at Sydney Observatory, December 7th, 1892.

By HENRY C. RUSSELL, B.A., F.R.S., F.R.Met.Soc.

Government Astronomer, Sydney, New South Wales.

[Received February 6th.—Read April 19th, 1893.]

THE storm came up at 8 p.m. when it was dark, there was no moon, and the photographs were taken at the times given below. The lens used was an old fashioned ½ plate Dallmeyer view lens, mounted in a whole plate camera with the object of getting a wide field. There is as a matter of course some distortion at the corners. The largest stop was used. The original photographs have been enlarged 2 diameters. The storm brought the finest electrical display we have had for some years.

It will be seen in reference to No. 2 that one of the flashes went down into the harbour, and the place is thereby so clearly marked that I have been able by the aid of the trigonometrical map to tell within 3 or 4 feet how far this point was from the Observatory, viz. 2,100 feet, hence with the known focal length of the lens I found that the length of this flash, so far as shown on this plate (probably not all of it), was 1,540 feet.

It will be seen that of the two flashes immediately behind this, one came down on the near side of the horizon, which would be about one mile from the one in the water, and the other beyond the horizon, probably 1½ to 2 miles away.

The plate was exposed for 4 minutes (and was an Instantaneous Marion plate), from 8.12 to 8.16 p.m.

These five flashes gave enough light to produce a faint picture of the landscape. If we assume the maximum duration of a flash, as given by the best authorities, to be $\frac{1}{100000}$ part of a second, then the landscape was lit up by the five flashes for $\frac{5}{100000}$ of a second, or $\frac{1}{20000}$. Now with the same camera and plates I am sure from experiments I have made that an exposure of that duration during the brightest sunshine would not give any sign of the landscape. I am unable to get an exposure of such a short period.

It will be observed that in the landscape there are white specks which represent the gas lamps in the streets. An examination of these points in the negative shows more clearly than can be seen in the print that these images are distorted towards the centre of the plate; and it should be mentioned that the centre of these prints is not the centre of the field of view of the lens. The distortion can be clearly seen on the right hand side of No. 1, and it is very marked in the lightning flashes. This plate was exposed two minutes, from 8.10 to 8.12 p.m., or immediately before plate No. 2. When examined with a lens these streaks have all the appearance of the so-called ribbon flashes, and an important point which is clearly seen in the negative, but is not visible in the print, is that on the side towards the centre of the plate the deposit of silver is not so great as it is on the other side of the ribbon flash. In fact, it would appear that the distortion in thickness of the flash is due to the same cause as the extension of the gas lamps, and it is on the same side. It seems obvious from these photographs that at least some ribbon-like flashes as shown in photographs have no objective existence.

Notes on Lightning Discharges in the Neighbourhood of Bristol, 1892.

By ERNEST H. COOK, D.Sc.

[Received December 2nd, 1892.—Read April 19th, 1893.]

The Bristol district was visited during the summer of 1892 by three thunderstorms which, in consequence of their violence, stand out preeminently as the most remarkable of the year.

(1.) *Storm of June 1st.*—The tree struck is a spruce, about 70 feet high, standing in Tyntesfield Park, Wraxall, very nearly at the top of the southern slope of Leigh Down. It forms one of the highest members of a somewhat thickly wooded copse, is 78 inches in girth at the bottom, and is still (September 15th) in full and vigorous growth.

The storm which caused the damage came from the south-west, and after passing over the low lying flat ground of Ken Moor and Nailsea, ascended the valley, passed over Leigh Down, and thence over Bristol, where one flash struck off a pinnacle of a wing of the University College, and another (? the same) destroyed the roof of the Retort House of the Gas Works. The velocity of the storm was high.

The mode in which the discharge affected the tree is very peculiar, and the case of the flag staff, described later on, is the only other instance that I am aware of where a similar effect has been observed.

The electricity seems to have struck the main trunk at a point about 1l feet from the top, and the portion above this point appears to be uninjured At the point of striking, the main trunk was stripped to a depth of about inches; a branch which sprang from this point was wrenched off and th wood torn into shreds, scattering the bark and portions of the wood to a con siderable distance around. It then descended the trunk, not in a straigh line, but in a very steep spiral. The side of the trunk, where first struck faces the north-east, and the turn downwards is towards the west. Th path of the electricity is marked by the bark being torn off and the woo shredded. This path makes one and-a-half complete turns around the mai trunk, the place where it reaches the earth being therefore on the south western side. The energy of the discharge, as evidenced by the path it ha marked out, is, however, not equal at all points. At the extreme bottom the width is about 1 inch, and the bark *only* is removed; 5 feet from th ground the width is 4 inches and the wood is shredded; higher still th width is a maximum of about a foot and the depth affected is about 3 or inches. The greatest action appears to have taken place at about the middle *i.e.* about 30 feet from the ground. Several branches were torn off by th discharge.

Probably the explanation of the peculiar path taken by the electricity is t be found in the distribution of water over the trunk, the resistance bein less by going around because of the fluid being thus distributed at that par ticular time. This explanation, however, is not without its difficulties, bu in support of it, I noticed that above the spot where the path commence the side of the trunk was covered for several feet with a large amount c fluid, apparently sap which had exuded from the point of junction of a branc still higher up. It must also be remembered that this portion of the tre (*i.e.* the top) would be first wetted by the storm, and it is therefore likel that when the tree was struck the topmost portion of the trunk was quit wet, and hence a comparatively good conductor. The electricity, therefore passed without doing any damage, but on arriving lower down the trun became drier, its resistance increased, and the electricity forced its wa under the bark and into the wood, to get the requisite conducting medium i the moist layer of cells immediately below the bark.

(2.) *Storm of July 18th.*—On Saturday, July 18th, the district was visite by what was generally described as the most severe storm for 20 years Rain fell in torrents. The lightning was frequent and very vivid. Th storm was also remarkable for its duration, lasting from 1 p.m. to abou 5 p.m. It came from a little to the west of south and with a low velocity During its progress a cedar tree growing in Tyntesfield Park, but down i the valley, was struck. It was about 50 feet high, with a girth of 77 inche at 5 feet from the ground. It was not so high as some trees in its neigh bourhood, and, although there was a small pond at some distance behind i yet some of these higher trees were much nearer to the pond. The tree wa completely shattered, the main trunk being broken off at about 15 feet from the ground and the branches and parts of the trunk being scattered in a

directions. Many of the pieces were firmly driven into the soil, one piece standing quite upright and being about 6 feet above the ground. The bark is stripped from portions of the main trunk, but not from the branches.

This discharge resembles, in an important respect, one which I described to the Society in February 1892,[1] viz. that the branches are uninjured except being torn off, whilst the trunk is violently affected. Two explanations may be given of this. First, the electricity may have run from the branches to the main trunk, but owing to the extent of their surface and the dampness with which they were covered, experienced little resistance to its passage, but on reaching the trunk the area of conducting surface suddenly diminished, and the wood was also drier. There was thus a sudden and large increase of resistance, in overcoming which the tree was completely destroyed. Secondly, the electricity may pass along the main trunk only, but at the junctions of the branches there will be a large increase of resistance owing to the discontinuity of the moist cells under the bark and the union of the woody tissue of the branch with that of the trunk. In forcing its way over this resistance the branch will be torn off. This explanation is somewhat supported by the spiral discharge of June 1st, where the path was on the trunk only, and those branches lying in the path were torn off, whereas the others were untouched.

(8.) *Storm of October 6th.*—This storm was less violent than either of those already mentioned, but during its progress the flag-staff placed on the summit of Brandon Hill, an elevation near the centre of Bristol, was struck. This was placed in the middle of a small cleared space of 40 feet diameter, which has been formed into a miniature fort. Brandon Hill is 259 feet above the sea, and forms the southern extremity of a high ridge of Millstone Grit, which runs in a north-east and south-west direction through the city. The staff was 58 feet high and surmounted by a movable vane, and was the most prominent object in its immediate neighbourhood.

The storm came up the Bristol Channel at a moderately high speed, reaching Bristol at about 8 p.m. The flash causing the damage was a very vivid one, rain immediately succeeding. The vigour of the discharge was so great that the damage could not have been caused by the main stroke. It was due to what may be called a lateral discharge.[2] In fact the flash appeared to me, looking from my laboratory windows, about 200 yards away from the staff, but hidden from it, as if it were going in a horizontal direction and not striking downwards. Its effect was to remove the vane, to strip a path on the pole, and to strike off a corner from the oak standard to which the pole was fixed.

The pole is marked in the following peculiar manner :—

Two faint markings occur at the top of the pole, the top of one being on the eastern side and that of the other on the western. These descend in a direction inclined to each other, and meet on the northern side at about 6 feet below the summit.

[1] *Quarterly Journal*, Vol. XVIII. p. 143.

[2] See the account of the Lateral Shock described in my paper, *Quarterly Journal*, Vol. XVIII. p. 143.

A single mark descends from the meeting place towards the west and south. When about west this surface marking ceases and a deep groove scooped in the wood commences. The groove continues around the pole towards the south, which it reaches at about 12 feet from the summit. It then turns back towards the west, but with a much higher inclination, and finally leaves the pole for the support on the north-north-west side. The general appearance of the groove can leave no doubt that the intensity increased as it approached the bottom.

On careful examination of this groove, which is about 1½ inch wide at the top and increases to 4 inches at the bottom, it was noticed that the central portion formed a kind of ridge, as if the force of the scooping had been less in that part; but this ridge contained splits some 4 inches deep, running into the centre of the pole. These splits only occurred in the ridge. The whole appearance was as if a chisel had scooped out the groove when held flat, but in the centre had been turned into a perpendicular direction and split into the wood.

The oak support, which is covered with a coating of tar, is 15½ feet high, and has an iron bolt passing through at some distance below the top. The electricity, therefore, left the pole and struck through to this bolt, tearing off the corner piece (6 ft. long) in its passage. It then ran over the flat surface of the oak on the western side, leaving its path shown by a characteristic marking. Thus it gained a piece of sheet zinc which was nailed around the bottom of the pole and support. This carried it to the ground, but not before it had struck into the wood again to reach another bolt, tearing open the wood in so doing and breaking off a piece of the zinc. There were no signs of charring or of fusion in any place, unless the surface marking on the tarred oak can be so called. This mark is 5 feet long and about 8 inches wide, and exactly resembles the mark produced on the surface of a non-conducting substance, by causing a highly condensed discharge to take place over its surface. For example, the mark may be imitated by charging a Leyden Jar until it discharges itself over the surface of the glass.

This discharge resembles the spruce (1) in the extreme top being uninjured; (2) in the spiral course of the electricity; and (3) in the character of the groove. Probably both were caused by lateral shocks, and not by the direct blow.

The trees resemble each other in one particular. They were, in each case, situated in the side of a group with an open space in front. The direction of the storm was such that in every case it passed over the main group of trees *first* and reached the damaged one *last*; apparently showing that the side which *receives* the storm was the one of greater safety.

CONSTRUCTIVE ERRORS IN SOME HYGROMETERS.

By W. W. MIDGLEY, F.R.Met.Soc.

[Received March 13th.—Read April 19th, 1893.]

Towards the close of 1892 I was commissioned to make an investigation into the hygrometrical conditions of a number of cotton mills in the Bolton district. A form of hygrometer (see fig. 2), in very general use in the cotton spinning and cloth industries since the provisions of the "Cotton Factories' Act of 1889" came into operation, was supplied for

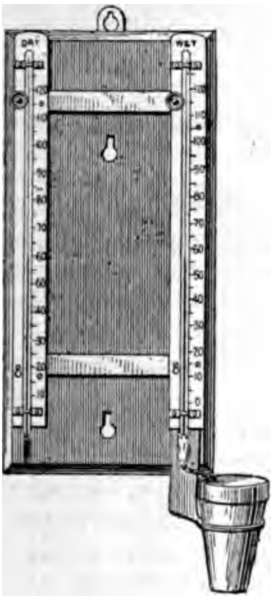

Fig. 1.—Casella's Pattern.

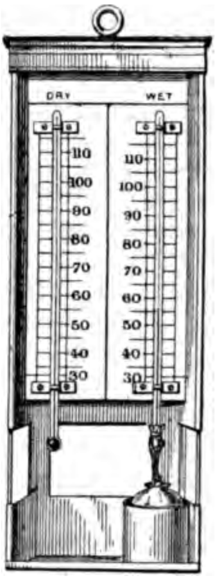

Fig. 2.—Mill Pattern.

making the observations. Noticing that the mounting of the thermometers and the position of the well of water did not conform to the rules recommended by Mr. Glaisher, or to Mr. Marriott's *Hints to Meteorological Observers*, it was decided to make a few test observations with one of the duplicate hygrometers we have for the Bolton Observatory, and see if there was any difference in the readings. The dry and wet bulb thermometers in use at the Observatory are of Mr. Casella's construction, bulbs 4 inches apart, with copper well, on cranked arm, to the right of the wet bulb, and tight fitting cover with small aperture for the conducting strands (fig. 1). In the "Mill" hygrometer, on the other hand, the thermometers were only 2½ inches apart, with glass well, placed slightly to the left of the wet bulb, and an aperture

⅞ inch wide; and, as sent out by the maker, an unnecessarily heavy amount of strands to convey the water to the muslin cover. A few exposures satisfied me that the "Mill" pattern, although the thermometers bore the Kew certifying marks, was defective when compared with the Royal Meteorological Society's pattern.

All the exposures to which this paper refers were made by suspending both instruments at the same time, one on each side of a supporting pillar, selecting the one as near the centre of the large rooms as possible, with the scales on the line of sight, and all the bulbs on the same level.

Table I. gives the readings of each instrument taken in different mills. Reduced, I find the relative humidity of each set, at temperatures of dry bulb between 80° and 90°, from ten exposures to be—Casella's 41·2 per cent., while the "Mill" pattern shows 50 per cent., or 19 per cent. too much: and from 90° to 100°, eight exposures, gives for Casella's 40·9 per cent., and the "Mill" 50·7 per cent., or 20 per cent. too much.

TABLE I.

READINGS TAKEN WITH MILL HYGROMETER, WITH WELL OF WATER IN THE POSITION AS SENT OUT BY MAKER.

Society's Form.			Mill Hygrometer.		
Dry-Bulb.	Wet-Bulb.	Humidity.	Dry-Bulb.	Wet-Bulb.	Humidity.
°	°	%	°	°	%
83·1	65·6	37	77·7	66·2	40
86·0	70·6	42	83·2	71·2	51
85·1	69·8	42	82·5	70·9	53
89·6	72·6	40	85·2	73·1	52
87·2	71·3	42	82·3	70·2	51
91·5	75·6	43	86·5	75·2	54
85·7	71·8	48	84·2	74·2	57
83·5	67·0	39	76·2	65·2	52
93·3	75·0	37	87·2	74·2	49
95·2	76·7	38	89·1	75·9	49
91·1	75·3	42	89·2	75·9	49
91·9	76·2	43	88·6	76·5	52
82·9	66·8	40	79·2	66·2	47
87·7	68·5	35	81·2	66·7	43
93·0	74·8	37·5	88·2	76·0	51
94·6	77·0	42	90·4	77·2	50
93·5	77·9	44	90·2	77·8	52
88·7	74·8	47	87·7	76·2	54

Then a series of readings were made with the well of the "Mill" form placed outside the wire cage on a temporary carrier, with the aperture of the well 4 inches from the dry bulb. While mounted in this position I also tried what the effect of wiping any moisture there might be from the dry bulb more or less frequently during the time the instruments were adjusting themselves to the temperature of the rooms. The details of the former plans will be found in Table II. At temperatures between 80° and 90° the humidity by Casella's instrument was 37·4 per cent., and the altered "Mill" pattern 47·2 per cent., on an average of four exposures = 20 per cent. too much: and between 90° and 100°, ten exposures, Casella's gave 35·8 per

TABLE II.

CHANGED THE WELL OF MILL FORM OUTSIDE WIRE SCREEN, SO AS TO BE 4 INCHES DISTANT FROM THE DRY-BULB.

Casella's.			Mill Form.		
Dry-Bulb.	Wet-Bulb.	Humidity.	Dry-Bulb.	Wet-Bulb.	Humidity.
°	°	%	°	°	%
93·5	73·9	35	89·0	73·2	41
93·7	73·6	34	90·4	73·2	40
96·1	74·3	31·5	91·9	74·2	38
86·8	68·9	36	82·2	67·2	42
90·6	73·5	40	87·6	72·8	43
87·0	69·3	37·5	82·1	68·2	45
96·3	77·5	37·5	95·0	78·2	41
90·6	72·9	38·5	89·5	74·2	42
92·5	72·2	33·5	84·2	72·2	51
93·6	72·9	32·5	90·2	73·2	40
91·6	72·6	36	88·8	72·9	41
80·6	64·1	38	74·6	63·3	51
91·3	72·1	35·5	88·9	73·4	42
96·4	75·1	33	90·9	74·2	41
83·7	66·7	38	78·0	66·2	51
99·0	75·0	30	95·2	74·2	33
95·6	72·7	30	93·4	73·2	34

cent. and the "Mill" 41·9 per cent., or 16 per cent. too much. The effect of wiping the dry bulb, particularly when done frequently, was to cause the temperature of the dry bulbs to agree very nearly. The results of eight observations between 80° and 90° showed Casella's 40·6 per cent., and the "Mill" 48 per cent., or only 5·6 per cent. too much ; and at from 90° to 100°, five observations, Casella's 35 per cent., and the "Mill" pattern 38·4 per cent., or 10 per cent. too much.

The reason for this variation may be attributed to : 1st, the well of water being too near the dry bulb ; 2nd, the thermometers being 1¼ inch too near each other ; and 3rd, an excess of strands connecting the well with the bulb. Moreover the effect of this grouping and evaporation from the open well and attachment has a deranging influence alike upon both bulbs, which is intensified in proportion as an increase of temperature takes place, increasing the humidity of the air immediately surrounding the instruments, decreasing its capacity to take up the vapour radiated off from the surface of the wet bulb, and causing it to read too high ; while the same local humidity condenses upon the dry bulb and reduces its temperature. This is borne out by a reference to the appended individual records, and those of the dry bulb in "Mill" hygrometer when wiped, as in Table III.

I also send the photographs of three other forms of "Mill" hygrometers which I came across in different mills (see Table IV.). Fig. 3: with fountain of water between the cylinders (the maker can never have read the introductory paragraph in Glaisher's *Hygrometrical Tables*) and bulbs 2⅝ inches apart. In this case Casella's gave 49 per cent. against 54 per cent. Fig. 4; bulbs *only* 1¼ *inch apart*, and a fountain to the right of the frame; Casella's gave 49 per cent. against 54 per cent. Fig. 5: bulbs 1⅝ inch

TABLE III.

OBSERVATIONS MADE WITH HYGROMETERS AS IN TABLE II., BUT THE DRY-BULB OF "MILL" FORM MORE OR LESS FREQUENTLY WIPED WITH DRY CLOTH.

Casella's.			Mill Form.		
Dry-Bulb.	Wet-Bulb.	Humidity.	Dry-Bulb.	Wet-Bulb.	Humidity.
°	°	%	°	°	%
85·1	69·8	42	85·4	71·7	47
89·1	72·5	40	87·9	72·2	42
87·0	70·0	39	85·8	71·0	45
88·3	69·0	34·5	87·9	68·7	35
98·6	77·4	35	96·4	76·4	35
96·7	77·5	37	93·6	78·4	45
90·8	70·8	34	89·0	72·2	38
80·7	67·1	46	79·6	67·7	50
85·0	61·8	27	84·2	62·2	28
102·4	79·6	31	100·1	81·1	38
99·6	78·6	34	98·2	79·2	38
89·3	73·8	42	89·4	75·3	46
92·0	71·8	33·5	90·2	71·4	36

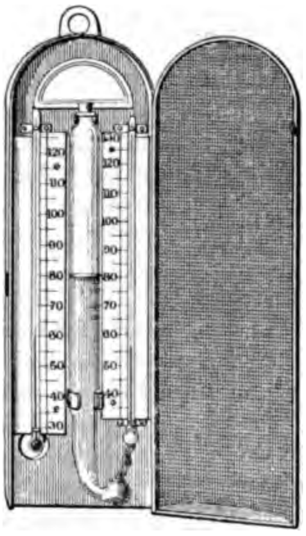

FIG. 3.

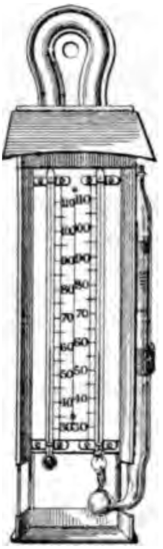

FIG. 4.

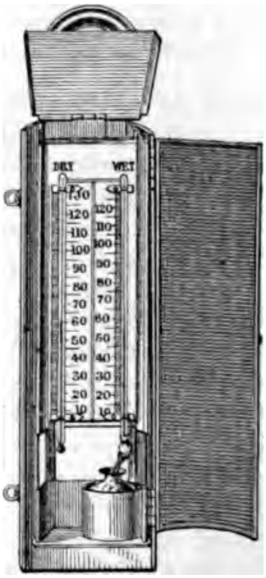

FIG. 5.

apart, and fountain as in fig. 4. Casella's gave 46·5 per cent. against 68 per cent., or not less than 26 per cent. too much. All these thermometers had been certified before mounting.[1]

Such striking discrepancies as these prove the necessity of following the instructions as to the manner of mounting a hygrometer laid down by re-

[1] In the "fountain" wells the aperture for the strands was a small one: hence there would be less evaporating surface exposed to the air; else the effect on the dry bulb would have been greater than in example I.

TABLE IV.

VARIOUS OTHER MOUNTS OF HYGROMETERS MET WITH IN USE AT MILLS.

Thermometers 1½ in. apart and fountain of water up the right hand. (Fig. 4.)

Casella's.			Mill Form.		
Dry-Bulb.	Wet-Bulb.	Humidity.	Dry-Bulb.	Wet-Bulb.	Humidity.
°	°	%	°	°	%
88·8	68·8	33	85·5	70·0	42
90·1	69·8	33	87·0	70·0	39
90·3	70·8	35	88·4	70·3	37
88·8	68·8	33	86·7	71·9	43

Thermometers 2¾ ins. apart and fountain of water between them. (Fig. 3.)

Casella's.			Mill Form.		
Dry-Bulb.	Wet-Bulb.	Humidity.	Dry-Bulb.	Wet-Bulb.	Humidity.
°	°	%	°	°	%
75·2	63·3	49	74·6	64·2	54

Thermometers 1¾ in. apart, and fountain of water to the right hand. (Fig. 5.)

Casella's.			Mill Form.[1]		
Dry-Bulb.	Wet-Bulb.	Humidity.	Dry-Bulb.	Wet-Bulb.	Humidity.
°	°	%	°	°	%
79·8	65·3	42·5	82·2	72·2	57
81·8	67·1	43·0	79·0	67·6	52
85·8	71·8	47·0	84·2	72·2	51
85·6	72·3	48·0	84·8	74·0	55
86·8	73·4	49	87·0	75·2	53
83·6	70·8	49	83·5	71·5	51

[1] I could find no evidence of these thermometers having been certified

cognised authorities in meteorology, and encourage me to submit the records as of some interest to the Fellows of the Royal Meteorological Society, and of great importance to the Cotton industry of the County of Lancaster. The Act of Parliament referred to prescribes the maximum weight of vapour per cubic foot of air at certain temperatures, and if the instruments supplied for determining the amount present in the mills have an error of 20 per cent. against the interests of the manufacturer, it becomes manifest that makers of these "Mill" hygrometers should adopt the Royal Meteorological Society's pattern for the purpose.

DISCUSSION.

Mr. SCOTT pointed out that it was hardly correct to speak of the "hygrometers" as having been verified at Kew, as simply the thermometers unmounted were sent to Kew for testing, and they were not verified as hygrometers. The question of humidity in cotton mills had arisen from the fact that in dry weather the thread will not spin, so artificial moisture had to be injected into the mills in order to make the atmosphere sufficiently humid to carry on the spinning. As

this injected moisture, if in excess, is injurious to the operatives, the Government have made it compulsory on the mill owners to have hygrometers in the mills for the purpose of regulating the degree of humidity, which is not allowed to exceed a certain limit. No provision had been made in the Act for the proper supervision of the instruments, and the result had been the state of things which Mr. Midgley's paper showed existed.

Mr. GASTER said that from observation and experiment he was satisfied that the proximity to the dry bulb thermometer of an open water receptacle, such as is ordinarily used in hygrometers, had no material effect on the reading of the dry bulb, although, by increasing the humidity of the air in the screen, it might, if too large, affect the wet bulb. He thought it probable that the difference between the humidity, as shown by the factory thermometers, and that shown by Mr. Midgley's standard, was due rather to the extraordinary mounting of the factory wet bulbs, which the diagrams showed to be very bad.

Mr. MARRIOTT said that he was very much surprised to hear Mr. Gaster say that the proximity of an open water receptacle to the dry bulb had no influence whatever upon its indications. He (Mr. Marriott) in December 1876 read a paper before the Society on "The Wet Bulb Thermometer," which contained a discussion of a careful series of observations made by Col. M. F. Ward at Rossinières, Switzerland, on dry and wet bulb thermometers mounted in various ways. Ten thermometers were employed as wet bulbs, which had different thicknesses of muslin and conducting threads, and with the water receptacles placed in various positions. In the set used as standards the bulb of the dry thermometer was 6 inches, and that of the wet 3 inches, from the water receptacle, which was a covered one. In one of the sets where the water receptacle was only ½ inch from the dry bulb, that thermometer read very much lower than the standard dry, 8·5 per cent. of the readings being as much as 1° less, and only 15·7 per cent. the same. When the water receptacle was placed ½ inch beneath the wet bulb and 1 inch from the dry bulb, the latter read lower than the standard dry bulb in fine dry weather, but when the air was damp and during rain it generally read higher. It was very desirable that the dry and wet bulb thermometers should not be less than 4 inches apart, and that the water receptacle should be still further from the dry bulb. The water receptacle also should have a cover to prevent evaporation, the cover having a small orifice for the conducting threads to pass through.

Mr. SYMONS said that he was greatly surprised at Mr. Gaster's remarks, as he felt it was impossible in the face of the figures contained in Mr. Midgley's paper to come to any other conclusion than that the differences in the indications of the hygrometers were due to the influence of condensation upon the dry bulb through the too close proximity of the water receptacle. Possibly the temperature and humidity at which Mr. Gaster made his experiments differed much from that in the mills, and perhaps that might account in some degree for the negative results which Mr. Gaster obtained. It seemed only reasonable to suppose that the effect of a vessel of water immediately beneath the dry bulb would be to alter the hygrometric state of the air.

Capt. TOYNBEE, in a note to the Secretary, said:—"I have often noticed that when the dry and wet bulbs have a certain amount of dust upon them, their difference increases a degree or more after washing the wet and dusting the dry bulb. My impression is that, owing to the ordinary handling of dry and wet bulbs at sea, they only give the *relative* humidity for different parts of the world and show a greater amount of humidity than that which really exists."

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

March 15th, 1893.

Ordinary Meeting.

C. THEODORE WILLIAMS, M.A., M.D., President, in the Chair.

Dr. JOSEPH SOFFIANTINI invited the Fellows of the Society to take part in the proposed Congress of Hydrology and Climatology to be held at Rome in September next. (See p. 156.)

Mr. SHELFORD BIDWELL, F.R.S., gave a Lecture on "Some Meteorological Problems," which was illustrated by experiments. (p. 161.)

April 19th, 1893.

Ordinary Meeting.

C. THEODORE WILLIAMS, M.A., M.D., President, in the Chair.

ROBERT LEAMAN BOWLES, M.D., F.R.C.P., 16 Upper Brook Street, W.;
ELIZABETH BROWN, Further Barton, Cirencester;
WILLIAM COULTHARD FALLS, M.A., M.B., M.R.C.S., 42 Montpelier Street, S.W.;
ROBERT LAMONT, Sturrock Street, Kilmarnock; and
ARTHUR RICHARD MANN SIMKINS, 86 Windsor Road, Ealing, W.,
were balloted for and duly elected Fellows of the Society.

The following Papers were read:—

"THE DIRECTION OF THE WIND OVER THE BRITISH ISLES, 1876-80." By F. C. BAYARD, LL.M., F.R.Met.Soc. (p. 172.)

"NOTES ABOUT TWO PHOTOGRAPHS OF LIGHTNING TAKEN AT SYDNEY OBSERVATORY, DECEMBER 7TH, 1892." By H. C. RUSSELL, B.A., F.R.S. (p. 192.)

"NOTES ON LIGHTNING DISCHARGES IN THE NEIGHBOURHOOD OF BRISTOL, 1892." By ERNEST H. COOK, D.Sc. (p. 193.)

"CONSTRUCTIVE ERRORS IN SOME HYGROMETERS." By W. W. MIDGLEY, F.R.Met.Soc. (p. 197.)

CORRESPONDENCE AND NOTES.

Kew Observatory.—Mr. Charles Chree, Fellow of King's College, Cambridge, has been appointed Superintendent of the Kew Observatory, which office had become vacant by the death of Mr. G. M. Whipple. Mr. Chree obtained in 1884 the hitherto unequalled honour of a first class in the most advanced parts both of the Mathematical and of the Natural Science Triposes, and he has since been much engaged at Cambridge in experimental and mathematical investigations. The results of these have been published in the *Cambridge Philosophical Journal* and in the *Philosophical Transactions* of the Royal Society.

The Helm Bar.—In a notice by Prof. Vidal, of Bastia, on the "Libeccio," or South-west wind of Corsica, which appears in the *Revue Maritime et Colonial* for May 1893, pp. 290-303, the following passage occurs:—"It is from the summits of the ridge that the 'Libeccio' descends on Bastia in impetuous squalls, with violence comparable to that of a hurricane. This plunging wind gives rise to some remarkable phenomena. During the squall enormous *cumuli* are seen to come up rapidly behind the mountain, and look as if they would cover the whole sky. But as soon as they have crossed the crest they disappear gradually, melting, so to speak, as they advance. This takes place because as they are swept down by the current they reach a higher and higher temperature, which vaporises them. But, at the same time, on the east side there are formed banks of cloud which are almost immovable. These clouds often present the appearance of a cuttlefish bone. They lie at the upper limit of the descending current, and at each squall they are seen to rise towards the west, under the influence of an ascending counter-current.

"This phenomenon can be easily reproduced if a horizontal jet of air from a pair of bellows is directed on the back of a book standing vertically on the edge of a table. It will be seen to blow out a candle on the ground below; but if the candle be moved to the upper edge of the current, an ascending counter current will be found."

[This notice appears to throw light on the formation of the Helm Bar of Crossfell.—EDITOR.]

Bangkok Rainfall.—Mr. C. S. Leckie has favoured us with the monthly rainfall for the 10 years, 1882-1891, as recorded at Bangkok, Siam, by the Borneo Company. In the *Quarterly Journal*, Vol. V. p. 82, will be found a paper by Dr. J. Campbell, R.N., giving the results of meteorological observations at Bangkok during the years 1858-1868, with the exception of 1862.

RAINFALL AT BANGKOK, SIAM, 1882–1891.

Months.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
January	·50	..		·10	..	1·79	..	5·10	·50	..
February	..	·63		3·62	·52	2·25	..	..	·50	5·80
March ..	·21	..		·12	·95	·87	..	1·15	..	1·62
April	4·52	3·06	7·00	1·35	·72	2·39	1·50	1·04	1·40	·46
May	5·92	7·44		1·52	7·72	8·76	13·25	6·97	8·52	1·33
June	3·78	9·69		8·88	8·49	4·19	1·40	5·81	5·68	1·77
July	8·43	2·10	5·29	6·78	10·97	7·97	4·05	3·88	4·01	4·54
August ..	3·07	5·76	3·57	10·96	4·02	8·75	6·39	10·64	12·14	5·29
September	14·15	8·57	6·18	14·12	16·41	9·61	11·34	16·07	10·26	7·10
October ..	11·56	3·44	8·49	9·06	12·85	6·98	6·58	11·14	5·00	6·93
November	1·50	1·52	3·23	3·35	3·12	1·56	1·50	6·76	·89	2·53
December	..	..	..	..	..	..	..	1·51	..	..
Year ..	53·64	43·21	33·76	59·86	65·77	55·12	46·01	70·07	48·90	37·37

Remarkable Hailstorms.—Mr. H. C. Russell, F.R.S., has communicated to the Royal Society of New South Wales some particulars of several violent thunder and hail storms which occurred in the district round Narrabri on October 18th, 1892. The following extracts show the violent character of the storms, and also the remarkable size of the hail stones:—

"At Tulcumbah, fifty-seven miles south-east from Narrabri, at 8 p.m. on October 18th, a violent thunder and hail storm broke over the homestead. It lasted half-an-hour, and Mr. A. D. Griffiths, my informant and manager of the station, says: 'I measured some of the hail stones, six-and-a-half inches in circumference; this was fifteen or twenty minutes after the storm, and I think I did not get the largest. Next morning I found that nineteen sheep had been killed by the hail, also birds, kangaroo rats, and other animals were found lying dead in all directions. All the windows exposed to the storm were broken, and the galvanised iron roofing was dented from end to end, and many sheets cut through; in several cases the hail stones went through the iron, in one sheet I found—thirty holes, and in another more than sixty. The bark of the trees in the storm track was all battered by the hail, and the fences and buildings bore traces of the impact of these great lumps of ice. The stones were generally triangular or conchoidal in form, many having an uneven surface, which looked as if it had been formed from frozen drops of water collected into masses; others had an opaque snow-like centre, perhaps the majority were like this, the remainder being like clear ice. It was only the larger stones that were irregular as described, the smaller ones were generally rounded.'

"At Avondale, thirty miles north of Narrabri, my informant, Mr. S. J. Dickson, says: 'From the 9th to the 18th of October the weather was unusually oppressive, with threatening storms, and on the evening of the 18th a heavy storm was seen to be working up from the west, accompanied by incessant lightning of every description, and about 8 p.m. it broke over the homestead in all its fury. The wind was from the South-west, and of terrific force, and the rain and hail were very severe. The hail stones were as large as hen eggs, and in some of the paddocks, one particularly, they pounded the herbage completely out, so that not a vestige of it was left, although before the storm came on it was from six to twelve inches high; in other places strong variegated thistles three to four feet high were beaten down. Trees some two feet thick, that the wind could not tear up by the roots, were snapped off short, as if made of matchwood. In the storm the hail killed birds innumerable, and even domestic fowls roosting on the trees were killed by it, and after the storm a large snake was found cut in two pieces apparently by the hail. On the open plain the hail lay four to six inches deep, and the whole country looked as if a heavy snowstorm had passed over it. Trees in the track of the hail were completely denuded of leaves, and the bark knocked off tree trunks and limbs. The storm wind carried away out-stations, unroofed the hay shed, damaged the wool shed, and carried away two sides of the house verandah, and the sheets of iron from it were found nearly half-a-mile (30 chains) away to the north-east, round wall plates in the hay shed, six to eight inches thick, were broken to pieces, and the iron roofing on all the buildings was battered by the hail as if someone had pounded it with a hammer all over. The storm track was only a mile to a mile-and-a-half wide, at least the hail part. Between 7 and 8 p.m., as the storm came up, there seemed to be a white bow in the sky like a white rainbow, stretching from north to south. I have seen heavy storms before, but I never wish to see another like this; the shearers were completely terrified, and all say that they have never experienced a storm like it,—in fact it beggars description, and can hardly be realised. It was an experience that we shall remember as long as we live.'"

Australian Weather—"The Southerly Burster."—The Hon. Ralph Abercromby has given to the Royal Society of New South Wales the sum of £100, which is to be offered as prizes, with the object of bringing about exhaustive studies of certain features of Australian weather.

So far only one feature has been selected, and a prize is now offered of £25 for an exhaustive study of the well-known "Southerly Burster." It is understood that no essay which does not deal fully with the following points will be considered:—

1. The motions of the various strata of clouds for some hours preceding, at the time of, and following the "burster."
2. The weather conditions which lead up to and follow the "burster," with Weather Charts of Australia for the day of and day following it.
3. The general conditions which modify the character of the "burster."
4. The area of the "burster" and its track.
5. Barograph traces showing the changes of pressure during the "burster."
6. The direction and character of wind preceding it.
7. The relation of "bursters" to rainfall.
8. The essay must not exceed 50 pages of foolscap.
9. The essay must be sent in not later than March 31st, 1894.
10. A photograph of each "burster" described, giving a characteristic view of the cloud-roll, should, if possible, be sent with the essay.

The essay must embody studies of several "bursters," and must be chiefly the result of original research of the author, but authors are not debarred from availing themselves of any available information, published or otherwise, on the subject.

Climate of the Island of Tobago.—The island lies between 11°·8′ and 11°·24′ N. lat. and between 60°·24′ and 60°·54′ W. long. Its longer axis, running from north-east to south-west, is 29 miles in length, and its breadth nowhere more than 9 miles. From observations made for a series of years by Mr. L. G. Hay, it appears that the yearly temperature ranges from a mean minimum of 78° in February to a mean maximum of 88° in September, while the mean for the whole year is 81°. The lowest absolute temperature observed was 68°, but it is very seldom that the thermometer falls below 71°. In May 1891 Baron Eggers recorded a temperature of 99°. The atmospheric pressure is also subject to small variations only.

In accordance with its latitude, the island has a rainy season lasting from the end of May to the end of December. Rain falls also, in smaller quantities, in the other months, and continued drought is quite an exceptional occurrence. In these months, however, the quantities of rain are less, and are distributed over a greater number of days. Whereas, for instance, the mean fall in September is to that of February in the proportion of 5 to 1, the rainy days are in the proportion of 4 to 3. Measurements made by Mr. F. Seeley at Courland Cottage, in the middle of the island, show that the average annual rainfall during the years 1874-81 was 71·11 ins., and the average number of rainy days 146. Among the wooded heights of the north-east the rainfall is no doubt much heavier, while towards the south-east it gradually diminishes. At Scarborough Mr. Seeley found the average for the years 1882-89 to be only 62·85 ins. Still less is the fall on the flat south-western foreland, where it barely attains a mean of 40 ins., and where the deficiency of moisture is manifested by the dry character of the vegetation. The climate of the neighbouring island of Trinidad is very similar, the yearly mean temperature at Port of Spain being 83°, and the annual average rainfall 70 ins. The higher temperature is due to the position of Port of Spain, which is sheltered from the Trade wind.

The prevailing wind in Tobago is the North-east Trade wind, which, however, at this distance from the equator blows pretty directly from the East, and is particularly strong from November to July. During the other months feeble and changeable winds, generally from the South, are experienced. In these months also occur the fearful hurricanes, which visit Tobago much less frequently than the islands further northwards, as Trinidad appears to lie quite outside their sphere.

In general, the climate, though hot, is healthy and agreeable. Fever seldom occurs, though occasionally it presents itself in a dangerous form.—*Scottish Geographical Magazine.*

RECENT PUBLICATIONS.

American Meteorological Journal. January-March 1893. Vol. IX. Nos. 9-11. 8vo.

The original articles are:—Data (chiefly meteorological) bearing upon the selection of stations for observing the total eclipse of April 16, 1893: by Prof. D. P. Todd (24 pp.). The author has collected all the cloud observations from stations along the line of totality, which will pass over Chili, Argentine Republic, Paraguay, Brazil, Senegal and Sahara.—A balloon ascent: by Prof. H. A. Hazen (4 pp.).—A study of departures: by H. Gawthrop (4 pp.).—The meteorological stations on Mont Blanc: by A. L. Rotch (3 pp.).—Statement of work of the New England Weather Service since the transfer from the New England Meteorological Society in March 1892: by J. W. Smith (7 pp.).—Anemometer comparisons: by S. B. Fergusson (5 pp.). Comparisons have been made at the Blue Hill Observatory between a Dines helicoid air meter and two Robinson anemometers of the U.S. Weather Bureau type, one with brass and the other with aluminium cups. The results show (1) that the Weather Bureau instrument registers higher than the helicoid, and that the differences apparently increase with the velocity; (2) that when the record of the Weather Bureau instrument is corrected by Prof. Marvin's table, it is considerably lower than that of the helicoid, at all except low velocities, notwithstanding the fact that the helicoid probably gives velocities slightly too low, on account of the sluggishness of the vane carrying it; and (3) that the brass cups apparently register higher than the aluminium cup, except at velocities below five miles an hour.—Hot Winds in Texas, May 29 and 30, 1892: by J. M. Cline (7 pp.).—The electrification of the lower air during auroral displays: by A. McAdie (5 pp.).—The paper mills and the fisheries; practical Koniology: by Prof. Cleveland Abbe (3 pp.).—The sling psychrometer: by Prof. H. A. Hazen (4 pp.).—The aspiration versus the sling psychrometer: by A. L. Rotch (3 pp.).—Exploration of the free air: by Prof. M. W. Harrington (7 pp.).—The general winds of the Atlantic Ocean: by Prof. W. M. Davis (13 pp.).—The colours of cloudy condensation: by Prof. C. Barus (34 pp.).

Annuaire de la Société Météorologique de France. July-August 1892. 4to.

Contains:—Variations locales de la température (le 31 mai 1892): par M. E. Bouvet (2 pp.).—Sur les températures moyennes diurnes de juin à Carcassonne (de 1873 à 1891): par M. Rousseau (2 pp.).—Résumé des observations météorologiques faites au Parc de Saint Maur, en mai et juin 1892: par M. E. Renou (2 pp.).

Meteorologische Zeitschrift. Redigirt von Dr. J. Hann und Dr. G. Hellmann. November 1892-April 1893. 4to.

The principal articles are:—Ueber den Unterschied der wahren Extreme des Luftdruckes und der zur Zeit der Beobachtungstermine: von Dr. H. Meyer (7 pp.). The author deals with the difference between the barometrical extremes as indicated by the ordinary observations, *e.g.* at the three hours of 7 a.m., 2 p.m. and 9 p.m., and the true extremes shown by barograms. The stations selected are seven in North Germany, and then Vienna, Pola, and New York.—Einige Wolkenbeobachtungen: von M. Möller (6 pp.). This is an interesting contribution to cloud study and nomenclature, carried out in Switzerland last summer, by marking the elevations on the mountains at which the several clouds floated.—Niederschlag, Gewitter und Bewölkung in einem Theile des Atlantischen Oceans: von Dr. P. Schlee (10 pp.). This is an investigation into the distribution of entries of rain, thunder and cloud over the route from the Channel to the River Plate, illustrated by two charts. It is, therefore, of the same character as the Dutch charts of *Storm, Regen, Donder, en Mist*, that appeared nearly 30 years ago, and were then noticed in the *Proceedings* of this Society, Vol. IV. p. 101, in a paper by Mr. Gaster.—Meteorologie des Ben Nevis: von Dr. J. Hann (16 pp.). This is an abstract and criticism of the various results of the Ben Nevis observations as published by Dr. Buchan and others.—Beziehungen der täglichen synoptischen Wetterkarten zur allgemeinen atmo-

sphärischen Cirkulation: von Dr. E. Hermann (19 pp.) This is an attempt to explain the general circulation of the atmosphere by means of the Weather Charts published by the Deutsche Seewarte and the Danish Office. The author classifies the cyclones under four heads, and the anticyclones under three. He then proceeds to deal with various theories of general atmospheric circulation, especially those of Maury and Ferrel, assuming with them that each hemisphere is divided into four zones, viz.:—1. Equatorial depression; 2. Tropical calms; 3. Depression of the West winds; and 4. Polar anticyclones. In his second paper the author principally deals with the isobaric surfaces and their inclination to the earth's surface, as shown on synoptic charts, and the influence of these directions on winds and the generation of storms. The paper concludes with an appeal for a cable to Iceland and Greenland, and for the continued publication of Atlantic synoptic charts.—Zur Theorie der Luftbewegung in stationären Anticyklonen mit koncentrischen kreisförmigen Isobaren: von Dr. F. Pockels (10 pp.). This is a mathematical discussion of the phenomena of wind motion in anticyclones.—Beobachtungen, betreffend die Absorption des ultravioletten Sonnenlichtes in der Atmosphäre: von J. Elster und H. Geitel (9 pp.). This is an account of a series of experiments made with an electrical actinometer destined to yield more satisfactory results than Langley's Bolometer, which hardly gives any indications of the ultra violet rays. The apparatus depends on the principle that by means of the dissipation of an electric charge from a cathode of amalgamated zinc the very faintest intensities of ultra violet light can be measured. The authors give the results of their observations for the three levels of the Sonnblick Observatory 3,100 metres, Kolm-Saigurn 1,600 metres, and Wolfenbüttel 80 metres, and then calculating the intensity of atmospheric action, they determine the amount of absorption, which is of course very much greater in the lower strata. Forty per cent. of ultra violet rays reached the level of the Sonnblick; 28 of these were absorbed before the rays reached Kolm-Saigurn, while on the way to Wolfenbüttel 47 per cent. of the remainder were lost.—Irisirende Wolken: von Prof. H. Mohn (17 pp.). The author had a good chance of determining the altitude of iridiscent clouds on December 19th, 1892, and in this paper he gives his calculations on the problem, and concludes with a request for further observations. He says that these clouds are always most frequent in winter and when storms are about, and that their level is far higher than that of cirrus.—Zur Bestimmung der Stärke einzelner Borastösse: von E. Mazelle (4 pp.). This is an account of some Bora observations at Trieste. This wind is notoriously violent and gusty. There are two anemometers, one on a building and the other on the Mole at the height of 33 feet, and he attempts to deduce constants in order to compare their indications. He uses the factor 3 throughout, and he gets velocities of gusts of about 100 miles an hour continued for a few seconds.—Ueber die Hypothesen der Oscillationen der sogenannten Maximalzone des Polarlichtes und über die Eigenthümlichkeiten der Entfaltung des Polarlichtes in dieser Zone: von A. Paulsen (10 pp.). This is a criticism by Dr. Paulsen on a theory propounded by Dr. Tromholt, that auroras have a diurnal oscillation northwards and southwards. This conclusion was disputed by Dr. Paulsen in his discussion of his Greenland observations, and Dr. Tromholt has replied to this in *Petermann's Mittheilungen*, Vol. XXXVIII., but in this latter paper he admits that the available observations are very scanty. Dr. Paulsen pertinently asks, in conclusion, what is the use of starting a theory if there are not sufficient observations to establish it.

Rainfall in the East Indian Archipelago, 1891. By Dr. J. P. van der Stok. 1892. 8vo. 415 pp.

This is the thirteenth annual volume, and contains the daily rainfall at 192 stations;—104 being in Java and Madura, and 88 in Sumatra and the different islands of the Archipelago. The tables show that during the year 1891 great drought prevailed throughout the whole of the Eastern Archipelago.

Report on the Meteorology of India in 1890. By John Eliot, M.A., Meteorological Reporter to the Government of India. 1892. 4to. 388 pp. and 5 plates.

[illegible] is the sixteenth annual report, and has been prepared on the same lines [illegible]receding volumes. Mr. Eliot says that the meteorology of 1890 has con-

firmed the conclusions given in the preceding annual reports of the remarkable persistency of the chief features of each season throughout. This persistency is as strongly exhibited in the North-east monsoon period as in the South-west monsoon, or period of rains. The cold weather of 1889-1890 was marked throughout by abnormal dryness and deficiency of rain. On the other hand, the South-west monsoon period proper was characterised by steadier and more abundant rain than usual. This remarkable persistency of the same general features through each of the large seasons in India necessarily implies that there must be equally persistent and general determining factors or causes. It would appear that these should be sought for in the variations of pressure in the higher as well as in the lower levels of the atmosphere from the normal, and the accompanying variations in the air motion over India. These variations in part determine the rainfall and are in part determined by it. The seasonal changes of temperature are undoubtedly of the utmost importance in explaining the general air motion over the Indian monsoon area, but the minor variations of each period (daily or monthly) appear to be chiefly determined by the occurrence and distribution of rainfall, and are hence mainly a result of, and not an influential factor in explaining, the stability and permanency of the chief features of each season in India (with a very few exceptions).

The chief features of the South-west monsoon period, and more especially the distribution of rainfall, appear to be largely determined by variations in the pressure conditions of the lower atmosphere in India itself immediately before and during the advent of the monsoon. These pressure conditions are doubtless largely determined by the character of the preceding cold weather, and of the snowfall in the Himalayan area, and partly by the character of the preceding hot weather. On the other hand, the character of the cold weather rains appears to be dependent on other causes than the distribution of pressure in India at the level of the plains. Usually in years of abundant cold weather rains pressure is considerably in defect at the higher Himalayan stations relatively to stations in Northern India, whereas in years of very deficient cold weather rainfall pressure is relatively largely in excess at these hill stations. These abnormal features are usually most prominent at Leh and Quetta. It is hence very probable that the character of the cold weather rainfall and snowfall in Northern India and the Himalayan area is mainly dependent upon conditions in the Central Asia elevated plateaux. The pressure conditions are undoubtedly communicated to the higher strata, but are obscured at the level of the plains by other causes. The extension of the work of observation in this direction which has been recently sanctioned by the Government of India will probably throw much light on this subject, and enable the general character of the cold weather rains to be judged with fair accuracy.

Scottish Geographical Magazine. January-April 1893. Vol. IX. Nos. 1-4. 8vo.

Contains:—The physical conditions of the waters of the English Channel: by H. N. Dickson (12 pp. and 2 plates). The paper gives the results of a physical survey of the western part of the English Channel, which the author made while acting as a member of the staff of the Marine Biological Association at Plymouth.—The climate of the Interior of Greenland: by Prof. H. Mohn (4 pp.). The author has discussed the results of the meteorological observations taken during Dr. Nansen's journey across Greenland in 1888, and has also examined the results obtained on Lieut. Peary's journey over the inland ice of Northern Greenland. Prof. Mohn is of opinion that the climate of Greenland is continental, with large ranges of temperature. The mean temperature for the year is low, and for the winter very low—perhaps the lowest to be found on the globe. In contrast to the climate of other continents, the summer temperature is also low, owing to the high latitude, the great elevation, and the vast extent of continuous snow fields. Both in summer and in winter the interior of Greenland contains a pole of low temperature, a centre of high atmospheric pressure from which anticyclonic winds radiate.—The distribution of temperature over the sea (6 pp.). This is a notice by Mr. W. A. Taylor of an article by Dr. W. Zenker which appeared in *Petermann's Mittheilungen.* The author draws the conclusions that abnormal heat is only produced (*a*) by the transference of

volumes of water from lower to higher latitudes, (*b*) through contact with land in latitudes below 40°, and (*c*) by warm winds, such as those which blow from the Atlantic. Depression of temperature, on the other hand, arises from (*a*) the transference of water from higher latitudes to lower, (*b*) contact with land in latitudes above 40° (particularly in the Polar seas), and (*c*) cold winds such as proceed from the Asiatic pole of cold.

Smithsonian Miscellaneous Collections.—The Mechanics of the Earth's Atmosphere. A Collection of Translations by CLEVELAND ABBE. 8vo. 824 pp.

During the past few years some of the fundamental problems of meteorology have been treated analytically and graphically with great success. Prof. Cleveland Abbe has collected all the memoirs that have been published on the mechanics of the atmosphere, and in the present volume gives a translation of twenty of the best memoirs, the authors being Prof. G. H. L. Hagen, Prof. H. von Helmholtz, Prof. G. Kirchhoff, Prof. A. Oberbeck, Dr. H. Hertz, Prof. W. von Bezold, Lord Rayleigh, Herr M. Margules, and Prof. W. Ferrel.

Symons's Monthly Meteorological Magazine. January-June 1893. 8vo.

The principal articles are:—The January frost (5 pp.).—Frost figures (3 pp.).—Distribution of rain in Mauritius during the decade 1881-90: by Prof. V. Raulin (3 pp.). The yearly totals mostly range from 60 to 100 ins., the highest, however, being 142·58 ins. at St. Hubert, and the lowest 29·66 ins. at Wolmar. As a rule, stations in the north, east, and south-east have the winter and summer wet, and those in the west and south have the winter and autumn wet and the spring and summer rather dry.—The Sandgate disaster, March 3rd, 1893 (5 pp.).—The Queensland Floods (3 pp.).—The Spring Drought of 1893 (5 pp.).—Rainfall at Chichester: by Dr. N. Tyacke (1 p.).—Rainfall in Brisbane: by J. T. Critchell (1 p.).—The Drought (2 pp.).—New issue of old meteorological books (3 pp.).—Maximum Shade Temperature in April 1893 (1 p.).

Transactions of the Seventh International Congress of Hygiene and Demography. Vols. I.-XIII. 8vo.

This Congress was held in London, August 10th-17th, 1891. Among the papers read were the following:—Town fogs and their effects: by Dr. W. J. Russell (12 pp.).—Meteorology in relation to Hygiene: by Dr. A. Buchan (7 pp.).—Influenza and the weather of London: by Sir A. Mitchell and Dr. Buchan (6 pp.).—Water supply: by A. R. Binnie (3 pp.).—The water supply of maritime towns: by Dr. E. F. Willoughby (3 pp.).—The influence of ground water upon health: by Baldwin Latham (4 pp.).—Tropical highlands; their suitability for European settlement: by Dr. R. W Felkin (10 pp.).—The suitability of tropical highlands for European settlement: by Sir W. Moore (6 pp.).—To what extent are tropical altitudes adapted for settlement by Europeans? by Dr. C. L. van der Burg (8 pp.).

U. S. Department of Agriculture, Weather Bureau. Bulletin No. 3. A Report on the Relations of Soil to Climate. By Prof. E. W. HILGARD. 1892. 8vo. 59 pp.

This report is of much interest, and shows great research. The concluding portions on the treatment of alkaline soils, such as are met with in parts of Hindostan, as well as in the Western States of North America, are particularly useful to those who have to deal with irrigation in India and Australia.

QUARTERLY JOURNAL

OF THE

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The Mean Maximum and Mean Minimum Temperature of the Air on each day of the year, at the Royal Observatory, Greenwich, on the average of the fifty years 1841 to 1890.

BY WILLIAM ELLIS, F.R.A.S.,

Of the Royal Observatory, Greenwich.

[Received March 25th.—Read May 17th, 1893.]

ONE result of the discussion of the observations and records of air temperature now being made at the Royal Observatory, Greenwich, for the fifty years 1841-1890, the mean temperature on each day of the year, as deduced usually from 12 or 24 observations daily, has already appeared in the *Quarterly Journal*, Vol. XVIII., page 239. By the kind permission of the Astronomer Royal, I am allowed now to supplement that table by two others, Tables I. and II., giving corresponding mean maximum and mean minimum values of temperature, as lately deduced from readings of the self-registering thermometers exposed on the revolving stand, for the same fifty years 1841-1890. From these are formed two additional tables, one, Table III., containing the daily range of temperature, and the other, Table IV., the simple mean

I.—MEAN MAXIMUM TEMPERATURE OF THE AIR ON EACH DAY OF THE YEAR, AS DEDUCED FROM THE READINGS OF A SELF-REGISTERING THERMOMETER AT THE ROYAL OBSERVATORY, GREENWICH, DURING THE FIFTY YEARS 1841–1890.

ay.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	°	°	°	°	°	°	°	°	°	°	°	°
1	42·38	44·51	46·42	54·96	59·71	68·95	71·23	74·17	70·73	63·71	52·85	44·54
2	42·11	44·61	47·90	55·45	60·51	70·27	72·57	73·64	70·40	62·32	53·05	44·55
3	43·34	44·78	47·68	55·69	61·65	70·33	73·32	73·08	70·28	62·54	52·41	45·37
4	43·17	44·62	48·22	56·42	60·04	70·75	74·24	73·80	70·40	62·00	52·51	45·65
5	43·35	45·30	48·76	56·17	62·33	69·67	75·02	74·12	70·36	61·70	52·66	46·75
6	42·35	45·32	49·23	56·43	62·45	69·17	74·16	73·89	70·14	60·59	52·23	46·60
7	42·19	44·93	49·07	56·42	61·96	69·15	73·28	75·03	69·67	61·81	51·48	45·35
8	42·23	44·80	48·85	55·65	61·29	68·93	72·87	74·14	68·83	60·63	51·10	45·16
9	42·14	43·18	48·16	53·43	61·99	68·70	73·56	73·99	68·95	59·06	49·68	44·38
10	42·23	43·74	47·86	54·42	62·03	68·74	73·93	73·59	68·41	59·95	49·31	43·20
11	41·83	43·06	47·84	54·76	62·39	69·69	73·06	73·60	68·54	59·06	48·88	43·55
12	41·48	44·18	48·32	55·39	62·86	69·75	74·56	74·07	69·30	58·93	48·26	43·62
13	42·74	44·14	48·43	55·15	63·10	70·75	75·66	74·44	68·36	57·81	48·08	44·84
14	42·53	45·67	48·86	55·89	62·83	70·73	75·56	73·36	67·71	57·82	48·81	45·04
15	42·25	46·19	48·97	57·10	63·71	69·96	76·24	73·36	67·88	57·71	48·18	45·26
16	42·85	46·42	50·26	56·88	64·76	70·50	74·54	72·90	68·17	57·35	48·08	44·78
17	42·69	46·95	49·51	58·04	63·28	69·86	74·41	72·32	68·20	58·14	47·03	44·01
18	43·52	46·07	50·50	58·13	64·31	69·48	74·55	72·22	67·03	56·33	47·37	44·40
19	43·41	45·04	50·07	58·93	64·84	70·56	73·89	72·07	66·40	56·79	48·22	43·54
20	42·28	44·66	49·36	60·71	65·23	71·42	74·41	71·51	66·25	56·13	47·26	42·77
21	41·83	45·74	47·98	59·77	66·08	72·21	74·71	71·93	65·30	55·52	47·30	42·93
22	42·77	46·02	49·26	58·40	66·19	72·50	75·17	72·26	65·40	55·96	47·96	42·98
23	43·56	46·02	50·34	59·01	66·79	72·71	74·02	71·40	64·12	55·20	47·41	42·62
24	43·27	45·79	51·89	58·20	67·50	73·02	73·30	72·22	64·31	55·16	46·72	42·42
25	43·95	46·70	51·20	58·69	67·10	72·17	73·45	71·80	64·94	54·16	47·11	42·11
26	44·32	47·09	51·14	59·69	67·20	72·87	73·96	71·68	64·41	54·02	47·33	42·43
27	45·05	45·99	52·06	59·30	67·65	74·12	73·82	71·84	64·58	53·63	46·50	42·79
28	44·97	46·84	52·47	59·57	66·46	73·01	73·07	72·13	64·12	53·77	46·20	43·01
29	45·38	47·92	53·30	58·37	66·62	73·66	74·17	70·79	63·71	53·49	45·88	43·65
30	45·07		53·45	60·21	68·22	72·09	74·42	71·46	63·37	53·50	45·03	42·93
31	45·36		44·45		67·43		74·06	70·70		53·61		42·75
		45·32	49·74	57·24	64·15	70·86	74·04	72·82	67·34	57·69	48·83	44·00

The mean of the twelve monthly values is 57°·93.

TABLE II.—MEAN MINIMUM TEMPERATURE OF THE AIR ON EACH DAY OF THE YEAR, AS DEDUCED FROM THE READINGS OF A SELF-REGISTERING THERMOMETER AT THE ROYAL OBSERVATORY, GREENWICH, DURING THE FIFTY YEARS 1841–1890.

Day.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	°	°	°	°	°	°	°	°	°	°	°	°
1	33.38	34.84	33.98	37.09	40.22	46.10	50.73	53.45	50.11	47.07	41.07	34.42
2	33.60	34.10	34.43	37.54	40.12	47.85	52.24	52.50	51.39	45.99	40.10	34.48
3	33.37	34.27	34.55	38.14	39.55	48.80	53.25	52.33	51.85	46.15	39.60	35.35
4	33.46	34.41	33.74	37.98	40.45	48.34	53.07	53.06	51.06	46.00	39.27	36.21
5	33.68	35.16	34.45	38.66	40.41	48.68	52.30	53.08	51.15	45.94	40.53	37.06
6	32.96	35.68	35.05	38.43	41.78	49.80	52.40	53.74	50.33	44.99	39.57	37.53
7	32.95	34.87	34.97	38.99	41.86	49.38	53.20	53.54	50.33	46.75	39.35	36.74
8	33.51	34.35	35.16	39.07	41.68	49.24	52.38	54.51	50.62	45.83	38.97	36.16
9	33.30	33.08	34.53	38.17	41.94	49.11	52.45	53.85	50.85	44.08	38.16	34.66
10	33.28	33.30	33.85	37.86	42.48	48.64	52.19	53.33	50.45	44.31	37.35	34.74
11	33.75	32.50	33.43	36.48	42.70	47.89	51.97	53.98	48.96	44.64	37.29	33.69
12	32.47	31.85	33.81	38.19	42.92	49.13	52.77	53.53	49.73	43.47	36.96	34.56
13	33.09	33.10	34.39	38.32	43.64	49.93	52.94	54.62	49.54	42.76	36.96	35.86
14	34.17	34.50	34.98	38.19	43.42	49.39	54.19	54.10	49.59	42.92	37.44	35.67
15	34.02	35.08	34.44	39.09	43.64	49.64	54.07	53.98	49.94	43.01	36.71	36.13
16	33.37	34.61	35.38	39.76	43.84	49.89	53.60	53.35	49.91	43.33	37.05	36.01
17	33.71	34.54	35.03	39.27	44.55	49.43	54.06	53.50	49.69	42.23	36.08	36.01
18	34.18	34.54	34.41	39.65	43.89	49.29	53.41	52.74	48.86	43.09	36.41	34.40
19	34.16	34.76	35.25	39.60	43.79	50.26	53.22	53.30	47.91	43.67	36.71	34.05
20	33.52	34.00	35.61	39.58	44.13	50.31	53.31	53.54	48.03	42.66	37.29	33.68
21	32.77	34.05	34.77	39.82	44.59	50.62	53.89	53.14	47.23	41.68	36.11	34.47
22	33.16	34.56	33.50	40.52	45.92	52.02	54.23	52.28	47.91	41.76	37.28	34.02
23	33.78	34.61	35.04	39.44	45.70	51.19	54.23	51.87	47.39	42.50	36.74	33.01
24	33.55	34.25	34.92	39.15	45.80	51.51	53.37	51.30	48.57	41.35	36.10	32.93
25	33.39	34.32	35.26	39.96	46.14	51.74	53.21	51.66	46.34	41.10	36.20	32.54
26	33.16	35.41	35.78	39.77	46.41	51.28	52.93	52.57	46.85	40.03	37.70	34.23
27	34.09	34.52	35.96	40.04	46.37	51.54	53.36	52.88	46.83	40.62	36.76	33.77
28	33.76	34.48	36.38	39.93	47.54	52.13	53.41	52.55	48.38	41.22	36.45	34.29
29	34.36	35.53	37.34	39.59	46.88	51.46	52.78	52.41	47.62	39.99	35.70	33.44
30	34.52		37.33	39.75	46.31	51.54	53.21	50.94	46.83	40.81	35.05	34.35
31	35.56		37.25		46.21		53.59	51.06		41.94		33.67
Means	33.61	34.29	35.00	38.93	43.71	49.87	53.10	52.99	49.14	43.29	37.56	34.78

The mean of the twelve monthly values is 42°.19.

TABLE III.—Mean Daily Range of Temperature at the Royal Observatory, Greenwich, 1841–1890 (being the [illegible] Maximum and Minimum Values on each day contained in Tables I. and II.)

Day.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	°	°	°	°	°	°	°	°	°	°	°	°
1	9·00	9·67	12·44	[illegible]	19·49	22·85	20·50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	8·51	10·51	13·47	17·91	20·19	22·42	20·33	21·14	[illegible]	[illegible]	[illegible]	[illegible]
3	9·97	10·51	13·13	17·55	22·10	21·53	20·07	20·73	[illegible]	[illegible]	[illegible]	[illegible]
4	9·71	10·21	14·48	18·44	19·59	22·41	21·17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	9·67	10·14	14·31	17·51	21·98	20·99	22·78	21·04	[illegible]	[illegible]	[illegible]	[illegible]
6	9·39	9·64	14·18	18·00	20·67	19·37	21·70	20·15	[illegible]	[illegible]	[illegible]	[illegible]
7	9·24	10·06	14·10	17·43	20·10	19·77	20·08	21·49	[illegible]	[illegible]	[illegible]	[illegible]
8	8·72	10·45	13·69	16·58	19·61	19·69	20·49	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	8·84	10·10	13·63	15·26	20·05	19·50	21·11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	8·95	10·44	14·01	16·56	19·55	20·10	21·74	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	8·08	10·56	14·41	18·28	19·69	21·80	21·09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	9·01	12·33	14·51	17·20	19·94	20·62	21·79	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	9·65	11·04	14·04	16·83	19·46	20·82	22·72	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	8·36	11·17	13·88	17·70	19·41	21·14	21·37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	8·23	11·11	14·53	18·01	20·07	20·32	22·17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	9·48	11·81	14·88	17·12	20·98	20·61	20·94	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	8·98	12·41	14·48	18·77	18·73	20·43	20·35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	9·34	11·53	16·09	18·48	20·42	20·19	21·14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	9·25	10·28	14·82	19·33	21·05	20·30	20·67	18·77	18·40	[illegible]	[illegible]	[illegible]
20	8·76	10·66	13·75	21·13	21·10	21·11	21·10	17·97	18·44	13·47	9·97	[illegible]
21	9·06	11·69	13·21	19·95	21·49	21·59	20·82	[illegible]	18·07	13·84	[illegible]	[illegible]
22	9·61	11·46	15·76	17·88	20·27	20·48	20·94	[illegible]	17·49	[illegible]	[illegible]	[illegible]
23	9·78	11·41	15·30	19·57	21·09	21·52	19·79	[illegible]	16·73	[illegible]	[illegible]	[illegible]
24	9·72	11·54	16·97	19·05	21·70	21·51	19·93	[illegible]	15·74	[illegible]	[illegible]	[illegible]
25	10·56	12·38	15·94	18·73	20·96	20·43	20·24	20·14	18·00	[illegible]	[illegible]	[illegible]
26	11·16	11·68	15·36	19·92	20·79	21·59	21·03	19·11	17·58	[illegible]	[illegible]	[illegible]
27	10·96	11·47	16·10	19·26	21·88	22·58	20·46	18·96	17·75	13·01	9·74	[illegible]
28	11·21	12·36	16·09	19·64	18·92	20·88	19·66	[illegible]	15·74	12·55	9·75	[illegible]
29	11·02	12·39	15·96	18·78	19·74	22·20	21·39	[illegible]	16·09	13·50	10·18	10·21
30	10·55		16·12	20·46	21·91	20·55	21·21	[illegible]	16·54	12·69	9·98	[illegible]
31	9·80		17·20		21·22		20·47	19·64		11·67		[illegible]
Means	9·50	11·03	14·74	18·31	20·44	20·99	20·94	19·83	18·20	14·40	11·26	9·22

The mean of the twelve monthly values is 15°·74.

TABLE IV.—MEAN TEMPERATURE OF THE AIR ON EACH DAY OF THE YEAR, AT THE ROYAL OBSERVATORY, GREENWICH, 1841–1890 (BEING THE SIMPLE MEAN OF THE MAXIMUM AND MINIMUM VALUES ON EACH DAY, CONTAINED IN TABLES I. AND II.)

Day.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	°	°	°	°	°	°	°	°	°	°	°	°
1	37·88	39·67	40·20	46·03	49·97	57·52	60·98	63·81	60·42	55·39	46·96	39·48
2	37·86	39·36	41·17	46·49	50·31	59·06	62·41	63·07	60·89	54·15	46·58	39·51
3	38·35	39·52	41·11	46·92	50·60	59·57	63·28	62·70	61·07	54·35	46·00	40·36
4	38·32	39·52	40·98	47·20	50·25	59·54	63·66	63·43	60·73	54·00	45·89	40·93
5	38·51	40·23	41·61	47·41	51·37	59·18	63·66	63·60	60·75	53·82	46·60	41·91
6	37·66	40·50	42·14	47·43	52·11	59·48	63·28	63·82	60·24	52·79	45·90	42·06
7	37·57	39·90	42·02	47·71	51·91	59·27	63·24	64·28	60·00	54·28	45·41	41·05
8	37·87	39·57	42·00	47·36	51·49	59·08	62·62	64·33	59·72	53·23	45·04	40·66
9	37·72	38·13	41·35	45·80	51·96	58·91	63·01	63·92	59·90	51·57	43·92	39·52
10	37·75	38·52	40·85	46·14	52·26	58·69	63·06	63·46	59·43	52·13	43·33	38·97
11	37·79	37·78	40·64	45·62	52·54	58·79	62·51	63·79	58·75	51·85	43·08	38·62
12	36·98	38·02	41·06	46·79	52·89	59·44	63·67	63·80	59·52	51·20	42·61	39·09
13	37·91	38·62	41·41	46·73	53·37	60·34	64·30	64·53	58·95	50·28	42·52	40·35
14	38·35	40·08	41·92	47·04	53·13	60·06	64·87	63·73	58·65	50·37	43·13	40·35
15	38·14	40·64	41·71	48·10	53·67	59·80	65·16	63·67	58·91	50·36	42·44	40·70
16	38·11	40·51	42·82	48·32	54·30	60·19	64·07	63·12	59·04	50·34	42·57	40·39
17	38·20	40·75	42·27	48·65	53·92	59·65	64·23	62·91	58·94	50·19	41·55	40·01
18	38·85	40·30	42·45	48·89	54·10	59·38	63·98	62·48	57·95	49·71	41·89	39·40
19	38·78	39·90	42·66	49·27	54·31	60·41	63·56	62·69	57·15	50·23	42·47	38·80
20	37·90	39·33	42·49	50·14	54·68	60·87	63·86	62·52	57·14	49·39	42·27	38·22
21	37·30	39·90	41·37	49·80	55·34	61·41	64·30	62·54	56·27	48·60	41·71	38·70
22	37·97	40·29	41·38	49·46	56·05	62·26	64·70	62·27	56·65	48·86	42·62	38·50
23	38·67	40·31	42·69	49·22	56·25	61·95	64·12	61·63	55·76	48·85	42·07	37·82
24	38·41	40·02	43·41	48·68	56·65	62·27	63·34	61·76	56·44	48·26	41·41	37·67
25	38·67	40·51	43·23	49·32	56·62	61·95	63·33	61·73	55·64	47·63	41·66	37·33
26	38·74	41·25	43·46	49·73	56·80	62·08	63·44	62·13	55·63	47·02	42·51	38·33
27	39·57	40·26	44·01	49·67	57·01	62·83	63·59	62·36	55·70	47·13	41·63	38·28
28	39·36	40·66	44·42	49·75	57·00	62·57	63·24	62·34	56·25	47·49	41·33	38·65
29	39·87	41·72	45·32	48·98	56·75	62·56	63·48	61·60	55·67	46·74	40·79	38·54
30	39·80		45·39	49·98	57·27	61·81	63·81	61·20	55·10	47·16	40·04	38·64
31	40·46		45·85		56·82		63·83	60·88		47·77		38·21
Means	38·37	39·80	42·37	48·09	53·93	60·36	63·57	62·91	58·24	50·49	43·20	39·39

The Mean of the twelve monthly values is 50°·06.

of the daily maximum and minimum values. In each of these tables the value for February 29 depends on 12 days only, consequently, in taking the monthly mean for February, proportionate weight only is given to the result for this day. The values are in all cases those given by observation, no smoothing process of any kind having been employed.

In a paper published in Vol. XVII. of the *Quarterly Journal*, page 289, I gave, for each month, the differences between the true mean temperature formed from twenty-four observations daily and that found by taking the simple mean of the daily maximum and minimum readings given by the self-registering thermometers, as determined from the observations of the twenty years 1849-1868. The recent collection of the Greenwich thermometrical results for the fifty years 1841-1890 enables us now to extend this comparison, not indeed to the fifty years, but to the forty-two years 1849-1890. For in the years 1841 to 1847 the daily values of mean temperature for Sundays have been formed from a few observations only on each day, and in 1848 from six observations on week days and fewer observations on Sundays. These were duly corrected, as necessary, for diurnal inequality, still it seemed better to confine the comparison to the years 1849-1890, in which the true mean temperature was throughout found from twenty-four observations daily, on Sundays as well as other days, excepting only in the case of occasional loss of photographic register, when eye observation values were used. The new numbers are as follows, adding thereto the corresponding numbers for twenty years spoken of above. The numbers apply to the middle of each month; proportion should be made for other parts of any month.

Month.	Excess of mean temperature, obtained by taking the simple mean of the daily maximum and minimum readings, above that formed from 24 observations daily. 1849–1890.	1849–1868.
	°	°
January	−0·2	−0·1
February	+0·3	+0·4
March	+0·6	+0·7
April	+0·8	+0·8
May	+0·7	+0·7
June	+0·8	+0·7
July	+1·0	+0·9
August	+1·2	+1·2
September	+1·0	+1·1
October	+0·4	+0·6
November	−0·1	+0·1
December	−0·3	−0·3
The Year	+0·5	+0·6

DISCUSSION.

Dr. BUCHAN said that he differed a little from Mr. Ellis in his explanation of the occurrence of the minimum temperature in February, and of the rise of temperature in August. The temperature of the ocean around the British Isles attained its minimum in February, and therefore it might reasonably be expected that in addition to the January minimum a reduction of temperature would take place during February. Then as regarded the maximum in August, he (Dr. Buchan) had found that the chief maximum temperature of the air occurred in July, but a secondary maximum took place in August, and this second rise of temperature appeared to be due to the fact that the temperature of the surrounding sea reached its maximum during August. With regard to the comparison between the mean 24 hourly observations of temperature and the simple mean of the daily extremes, he had found that the agreements between these values was very fair, except in those cases where the hourly observations were incomplete through defects in registration, and then the differences were often considerable. He supposed that in the figures submitted by Mr. Ellis any hourly observations which were wanting had been made good by interpolation.

Mr. SYMONS remarked that the differences given in the table of comparisons appeared, as far as he could remember, to closely resemble the corrections to reduce the arithmetical mean of the maximum and minimum to true mean temperature as determined by Mr. Glaisher. He thought that this correction depended on the pattern of stand used. As regarded the deviation between the two sets of monthly averages for the fifty years, it was perhaps due to difference in exposure, the mean of the hourly observations being obtained from the photographic records (the thermometers and apparatus connected with which were mounted in a large shed), while the means of the observations of the daily extremes were from maximum and minimum thermometers exposed on a revolving stand. It was probable that if a Stevenson screen had been used for the purpose of exposing the self-registering thermometers, the results would have accorded more closely with those from the photographic records, as it was well known that in the summer months the range of temperature on a revolving stand is larger than that shown by thermometers in a Stevenson screen.

Dr. BUCHAN observed that the deviation shown in the second column of the statement referred to by Mr. Symons was not more than half the amount of the corrections given by Mr. Glaisher. He considered that it was entirely wrong to apply Mr. Glaisher's corrections to observations made in Stevenson screens.

Mr. HARRIES remarked that Dr. P. Bergholz had published a very complete discussion of observations of daily maximum and minimum temperatures and other elements at Bremen for the years 1808 to 1890, so that Mr. Ellis's results were not the first of their kind.

Mr. SOUTHALL said that the date of the extreme minimum in January was exactly midway between the date given by Luke Howard (January 18th) and that given by Mr. Glaisher (January 6th-7th), Mr. Ellis's date being January 12th. Regarding the wave of heat in August, he had noticed that heavy thunderstorms frequently occurred on August 18th.

Mr. ELLIS said that in calling the February minimum of air temperature accidental he was aware that he was using too strong a word; he was not so well acquainted with the variations of ocean temperature. The mean daily air temperatures given in the *Quarterly Journal*, Vol. XVIII., page 289, are the means of separate daily values, found either from actual readings of the thermometer of the revolving (Glaisher) stand, or from photographic values reduced to the reading of the same thermometer, and thus become strictly comparable with the simple means of readings of the maximum and minimum self-registering thermometers placed on the same stand as given in Table IV. of the present paper; consequently the differences between the two sets of means are not, as suggested, due to difference of exposure. For the reason stated, however, the comparison has been confined to the years 1849-1890 (42 years). The differences given are less than those formerly found by Mr. Glaisher, which were determined from the observations of a few years only. No doubt they depended in a measure on the pattern of stand employed; it would thus be improper to use them

to correct the mean of the maximum and minimum, as observed in a Stevenson screen, for which the correction would likely be different, probably less in magnitude. We should not necessarily expect the simple mean of the maximum and minimum to agree with the true mean even under the same conditions of exposure, or consider a close agreement in this respect, in any particular form of screen, as indicating that on this account the screen was in principle superior, although such agreement from a practical point of view may be convenient.

Suggestions, from a practical point of view, for a new Classification of Cloud Forms.

By FREDERIC GASTER, F.R.Met.Soc.

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The forms assumed by clouds at different levels, and found under various conditions, have recently received a large amount of attention from meteorologists. This increasing interest is probably due, to a very great extent, to the facility with which most of the forms may be photographed. Even the difficulties which, for a time, lay in the way of photographing clouds of the *cirrus* type—especially when appearing in bright sunshine—are being overcome by one of our Fellows, Mr. Clayden, whose kindly aid will enable me this evening to place before the Fellows a number of lantern illustrations, which will make my proposals more readily intelligible. The labours too of Hildebrandsson, Abercromby, Ley, Singer, and others have brought before meteorologists cloud photographs, arrangements of them, or views with regard to them, intended to replace the nomenclature of Luke Howard and the somewhat defective drawings with which one edition of his work was illustrated. Mr. Ley has been working for years, and some contributions from his pen have greatly aided those who have studied clouds. I do not propose, however, to take up the time of the Society by enumerating all or even many of the classifications which have been placed before the world, but, in looking back, shall refer mainly to those of Luke Howard, and of Hildebrandsson and Abercromby, as being probably the best known.

In examining the different collections of photographs which are open for inspection, I cannot help feeling that an enormous excess of attention has been devoted to those forms (such as *cumulus*) which lend themselves most readily to the artist in producing good pictures, with the result that certain of the cirriform and stratiform varieties have been almost or altogether passed over. One of the objects kept in view in preparing this paper is to show where some such blanks exist, in the hope that they may be soon filled up.

I do not intend to criticise at any length the nomenclatures and classifications which have been proposed in late years, except to say that while they are accompanied by greatly improved cloud pictures, the nomenclatures

proposed appear to be little if any better than the older ones they were intended to replace. I allude more particularly to the terms *cirro-cumulus*, *cumulo-cirrus* and *alto-cumulus*, as used by Abercromby and Hildebrandsson in their work, and as reproduced in the Hamburg "Cloud Atlas" 1890. Perhaps if every observer were an adept at cloud observing these defects would be reduced to a minimum—but this is not so. A large number of observers know very little about clouds, and, owing to want of clearness in stating the principles on which the names have been given, they are unable to discover, with the limited time at their disposal, where to place, or how to describe, those they see. I do not pretend that the proposals about to be made will settle *all* the difficulties which arise in this matter—it is impossible that a question of such breadth should be dealt with fully in one paper—but I hope that they will form a step in advance, and aid beginners to grasp the subject in its more prominent bearings more readily and more logically.

I shall first state briefly the principles on which the present proposal is based. Simultaneously with Capt Wilson-Barker, one of our Fellows, I came to the conclusion (as stated in the discussion which followed his paper[1] on February 19th, 1890) that there are, in fact, only two main classes of cloud-forms;—(1.) Those which arrange themselves in the form of sheets—whose vertical measurements are small when compared with the horizontal. To these both he and I apply the general terms *stratus* or *stratiform*. (2.) These which rise up in heaps (like masses of cotton wool) from a horizontal base; and to these we apply the terms *cumulus* or *cumuliform*. If I understand him rightly I may say we look upon cirrus and cirriform clouds as modifications of the stratiform, and believe that by adopting these two main terms, and supplementing them by a few well-known prefixes or affixes, we may describe all the forms at present recognised, and have a classification leaving room for embracing other forms not yet clearly defined. In doing this, care has been used not to violate the meaning of any of the terms hitherto used by Howard—but rather, by slight modifications, to enlarge their scope, so that while that is still applicable to the cloud which it originally represented, it becomes the general term for many others of the same type.

The prefixes and affixes employed in this paper are mainly the following:—

Detached, applied to sheet-clouds when the sheet is broken up into a number of more or less rounded cloudlets—such as is found in the conventional *cirro-cumulus* cloud.

Fracto, applied to clouds, or portions of clouds, with ragged edges—bearing the appearance of having been broken roughly off from a larger mass, or of having their outline broken or torn owing to some atmospheric disturbance.

Turretted, when portions of the cloud rise abruptly from the base,

[1] *Quarterly Journal*, Vol. XVI. p. 131.

in a turret-like form, at considerable distances from one another. [This term was, I believe, proposed first by Mr. Ley.]

Mammato, when, instead of the rounded portion of certain clouds rising upward from a base, they hang downwards somewhat in the form of mammæ. Instances of this occur both in stratiform and cumuliform clouds.

Furrowed, applied to certain forms of stratus cloud, the under surface of which is in ridges, as though it had been ploughed, as a field.

Cirriform, to those clouds which, while appearing as sheets, or parts of sheets, have a distinct filamentary structure either in right or curvilinear lines, or take the form of feathers, delicate seaweed, &c., or have a "fretted" appearance.

I propose to reject "ground fog" entirely from the forms of "cloud," and to consider as "clouds" only those bodies of water- or ice-dust which float in the air at a greater or less distance from the surface of the earth in comparatively level places.

With these principles in view I have drawn up the accompanying Table;—in it all the cloud forms with which I am acquainted as being satisfactorily identified are classed under four headings, viz.

1. Surface Clouds, or those which appear commonly between the earth's surface and a level of about 2,000 feet, at which latter altitude the bases of some of the *cumulo-nimbi* (in Class 2) are occasionally found.

2. Lower Medium Clouds, commonly found at an altitude varying from 2,000 to about 10,000 feet from the earth.

3. Higher Medium Clouds, including all varieties which usually float at an elevation ranging from 10,000 to about 22,000 feet.

4. Highest (or Cirriform) Level Clouds, or those found commonly at elevations exceeding 22,000 feet.

The altitudes are taken from the Hamburg "Cloud Atlas."

Columns are given in the Table furnishing:—(1) The names of each variety of cloud included in the classification; (2) A short account of the principal characteristics of each as far as appearance goes; (3) A reference to certain photographs or other pictures in possession of well-known authorities, and in which the variety is represented: (4) The names hitherto applied to the variety by some well-known authority; and (5) A convenient abbreviation by which its appearance might be recorded in an ordinary Meteorological Register.

The limits of altitude, separating class from class, are by no means hard and fast lines, nor are the altitude values quoted to be taken as severely accurate, but rather as being a good approximation to the limiting heights of the zones in which the varieties in each class ordinarily appear over the northern half of Europe. Cirriform cloud is occasionally found at much

lower levels than 20,000 feet; in fact, some lower medium clouds have been observed to assume a cirrus-like shape at times. Such occurrences are noteworthy and point to an unusual condition—and a good observation of such an occurrence will naturally suggest to an investigator the necessity for considering what the conditions are which contributed to such an erratic development.

The appearance of the clouds is described in the table in sufficient detail to enable observers to recognise them. It is not proposed to print illustrations with this paper, but in discussing more fully, at a future time, each of the varieties, I hope to supply the need. The term *stratus*, as applied to the surface clouds, has been most unwillingly retained; in many cases these clouds do not assume a sheet-like form at all, but it has been a common practice to call all fog-like and ill-defined forms "stratus." The vertical measurement of fog banks (S. Det. 1), when compared with the horizontal, is usually very considerable; the large serrated stratus clouds (S. Neb. 1) and stormy scud (S. Fracta 1) have no regular form at all, and although the high fog (S. Con, 1) has the appearance of a sheet when viewed from beneath, its vertical thickness must often be great, or it could not otherwise produce the midnight darkness it often does over London even when there is little fog near the ground. I make this protest, inasmuch as to adopt the term, even for a time, is to break somewhat rudely the definition given earlier in the present paper. Perhaps it would be better to include these "fog banks" in the *cumulus* family; the lowest forms of cloud to which, in my opinion, the term *stratus* is applicable being the "anticyclonic stratus" of Ley, and the "strato-cumulus" of Hildebrandsson and Abercromby—both of which I have included in Class 2.

A remark is necessary also with regard to a form of *cumulus*—not well developed—a picture of which is given in photo 16 of Hildebrandsson's *Classification des Nuages*, Upsala 1879. Such clouds often accompany local thunderstorms and appear at a very low level; it is stated that an observer at the summit of the Eiffel Tower has witnessed a storm passing over Paris below his feet, he himself being in bright sunlight. However this may be (my authority is not very good), I have seen such clouds once, below the level of the summits of hills about 600 feet above the mean sea level. I have not tabulated this variety, as I should like to know a little more on the subject before concluding whether the cloud is an independent variety or merely an offshoot from a large *cumulo-nimbus*, the form of which is concealed from an observer.

The views propounded in this paper seem to me to be an advance on those recently advocated in the following particulars:—

1. The number of distinct varieties of form here recognised and described is larger than that included in the papers by the authorities to whom I have already so often referred, but I believe they are classified in a more simple manner, and are consequently easy to remember.

2. The proposed arrangement brings out the fact that clouds having the same general form, but appearing in more than one of the classes, are found to

TABLE—SHOWING THE CLASSES OF CLOUDS AND THEIR APPROXIMATE ALTITUDE ABOVE THE MEAN SEA LEVEL, THE NAMES OF VARIETIES, WITH A DESCRIPTION OF EACH, AND A REFERENCE TO THE PICTURES WHICH HAVE BEEN CONSIDERED IN CLASSIFYING THEM, TOGETHER WITH SOME ABBREVIATIONS SUGGESTED FOR USE IN REGISTERS.

Names proposed for each Variety.	Description of Main Characteristics.	Pictures and Photos used in preparing Classification.	Names hitherto applied to each Variety.	Abbreviations for use in Registers.
	CLASS 1. SURFACE CLOUDS. 0 TO 3,000 FEET.			
Hazy Stratus 1*	Patches of thin haze, often serrated; most common in early morning, in fine weather	Aber. Cloud Atlas, pl. 10	Serrated Cloud (Abercromby) or (?) Stratus (Howard)	S. Neb. (1)
Detached Stratus 1†	Large masses of fog detached from one another and drifting at very low elevation—their lower extremities sometimes touching the ground—commonly called "Fog Banks." Tops often rounded somewhat, but not sharply defined. Seen when thick continuous fogs are "lifting," and dispersing slowly	None	?	S. Det. (1)
Fracto Stratus 1	Low scud, often drifting with great rapidity at very slight elevation—(sometimes of a few hundred feet)—during gales with rain	None	Fracto-Stratus	S. Frac. (1)
Continuous Stratus 1	(*a*) Dense thick sheet of cloud—very uniform—often covering the whole of the sky. No well-defined outline. Sometimes called "high fog," and frequently causing intense darkness (especially over London) even at mid-day (*b*) Also a sheet of fog-like cloud of less density, occasionally seen drifting with great rapidity across the sky when weather at earth's surface is quiet	None	High Fog	S. Con. 1 (*a*) S. Con. 1 (*b*)
	CLASS 2. LOWER MEDIUM CLOUDS—3,000 FEET TO ABOUT 10,000 FEET.			
Cumulo-Nimbus 2	Very heavy masses of cloud, of great vertical thickness, rising from a horizontal base. Summits attaining great altitude (sometimes 16,000 ft.); sometimes rounded, but more often either of an "anvil" form, or breaking up into a cirriform shape (called "false cirrus") which increases as the cloud gradually breaks up. At times the summit of cloud is inosculated in a sheet of superincumbent stratus, and unites with it and forms "false cirrus" as above	Hild. 15; Cloud Atlas 9; Aber. 39 (for base) 88, 100, and many by Riggenbach and others	Cumulo-Stratus (Howard), Cumulo-Nimbus, and the "Shower Cloud" of Ley	Cum. Nim. (2)
Cumulus 2	Well defined clouds, rising in rounded masses (like heaps of cotton wool) from a horizontal base; increasing in altitude in thundery weather, when portions of the cloud rise as lofty columns above the adjacent portions, and sometimes change into cum. nim. 2	Howard, Poey, Hild. 14, Aber. (numerous), Cloud Atlas 8, Riggenbach and others	Cumulus	Cum. (2)

* To be called Foggy Stratus (S. Fog 2) when dense. † Have never seen these referred to, except as "fog banks," but probably Howard would have included them as *Stratus*.

Continued.

Names proposed for each Variety.	Description of Main Characteristics.	Pictures and Photos used in preparing Classification.	Names hitherto applied to each Variety.	Abbreviations for use in Registers.
	CLASS 2. LOWER MEDIUM CLOUDS—3,000 FEET TO ABOUT 10,000 FEET—*Continued.*			
Mammato-Cumulus 2*	Apparently a form of inverted cumulus, having the rounded portions extending downwards instead of upwards. The rounded protuberances, however, differ considerably in form from those of the true cumulus, and, in fact, in Russell's photographs some of them are in the form of "button" mushrooms	Mr. Russell's Photo in possession of this Society, and Picture in a paper by Dr. Clouston in *Phil. Mag.* 1857	"Pocky Cloud"	Cum. Mam. 2
Fracto-Cumulus 2	Cumuli dispersing—rounded form giving way to a very ragged and loose structure. The scud of gusty windy weather	Poey	Fracto-Cumulus (Poey)	Cum. Frac. (2)
Strato-Cumulus 2	Sheet of detached cloudlets, with somewhat rounded periphery, their summits rather cumuliform, but elevation of summit above base much smaller than in true cumulus. Commonly passing into the "S. Det. 2"; at other times developed from that form	Hild. 13; Aber. 105; Cloud Atlas, No. 6, and Singer No. 7	Strato-Cumulus, the "Roll Cumulus" of Toynbee	S. Cum. 2
Detached Stratus 2	Sheet cloud broken into somewhat rounded (detached) cloudlets; flatter than those named above, but of considerable and uniform thickness	? Hild. 11; Riggenbach 235, Singer 8, (not very well defined)	Medium Stratus	S. Det. 2
Fracto-Stratus 2†	A loose scud-like cloud of no definite form, very similar to Fracto-cum., and floating at about same level, but without any tendency to rounded form or horizontal base. Often seen with fr. cum., and hard to distinguish from it	None	?	S. Frac. 2
Continuous Stratus 2	A continuous sheet of uniform cloud, forming a complete pallium; often appearing in dry anticyclonic weather, and hence frequently termed "Anticyclonic Stratus." Causing gloomy weather; edges well-defined where an opening occurs	Ley (Modern Meteorology) where an opening is shown to indicate clearness of sky above the canopy	Anticyclonic St.	S. Con. 2
Strato-Nimbus 2‡	A sheet of composite cloud (cumulo-cirro-stratus or "rain cloud" of Howard) covering the whole sky, but limits of under side not very well-defined. Often very dense and causing great darkness—upper surface cirriform	Singer 11, and some by Aber. Howard (bad). Difficult but not impossible to give photo of cloud in its perfect form	"Nimbus" or "Rain Cloud" (Howard) and "Strato Nimbus" of more recent writers	S. Nim. 2

* This variety is said to be followed by or to accompany thunderstorms. † This cloud and Frac. Cum. 2 might perhaps be classed together—their points of difference being so *very* slight. ‡ When rain is not actually falling but canopy complete, it is hard to say whether that cloud is a S. Nim. or S. Con.

TABLE—SHOWING THE CLASSES OF CLOUDS AND THEIR APPROXIMATE ALTITUDE ABOVE THE MEAN SEA-LEVEL, THE NAMES OF VARIETIES, WITH A DESCRIPTION OF EACH, AND A REFERENCE TO THE PICTURES WHICH HAVE BEEN CONSIDERED IN CLASSIFYING THEM, TOGETHER WITH SOME ABBREVIATIONS SUGGESTED FOR USE IN REGISTERS *Continued.*

Names proposed for each Variety.	Description of Main Characteristics.	Pictures and Photos used in preparing Classification.	Names hitherto applied to each Variety.	Abbreviations for use in Registers.
	CLASS 3. HIGHER MEDIUM CLOUDS—10,000 FEET TO 22,000 FEET.			
Continuous Stratus 3*	A sheet of uniform density and thickness often covering the whole sky. Commonly developed beneath a stratum of Sheet Cirrus, when the South winds of an advancing depression are advancing. Sun and moon can be dimly seen through it, but it usually happens that, with the development of further thicknesses of cloud beneath, the cloud sinks and changes into S. Con. 2 or S. Nim. 2	Cloud Atlas, plate 5 No Photo	One form of Alto Stratus	S. Con. 3
Furrowed Stratus 3†	A sheet cloud, the under surface of which appears to be furrowed like the surface of a field recently ploughed	Riggenbach 139 and 149	?	S. Fur. 3
Lenticular Stratus 3‡	A sheet cloud broken into portions, having the form of a vertical section of a lens (concavo-convex or plano-convex). Often very dense and most commonly seen in very rainy weather	No good one. Specimen partially developed; shown in slide	Lenticular Stratus (Ley)	S. Len. 3
Detached Stratus 3§	A sheet of Stratus broken into small rounded cloudlets, which appear either in patches or as a vast sheet, covering the sky sometimes with well-defined outlines and irregular spaces between their margins. [Called by many "Mackerel sky"]	Cloud Atlas, Photo 4; Singer No. 4; Aber. many; Hild. 10	Cirro-cumulus (Howard; Alto cumulus by more recent writers	S. Det. 3
Rippled Stratus 3	Similar to above, but cloudlets elongated—sometimes well-defined, sometimes soft and woolly at edges	Hild. 9; Cloud Atlas, Photo 3; and ? pl. 4; Singer 5; Riggenbach 54 and 107	Cirstr. or Circum (Howard): Alto Stratus later writers	S. Rip. 3
Mammato Stratus 3‖	A sheet of Stratus cloud, having small rounded protuberance (like mammæ) from its wider surface, causing the lower surface of the clouds to have much the appearance assumed by boiling wax—only that the protuberances spread downwards, and do not change rapidly		Mammato Stratus	S. Mam. 3
Turreted Stratus 3	A series of protuberances rising from a horizontal base; said by Mr. Ley to be an almost certain indication of thunderstorms or lightning. One of the highest varieties in the classes, and, in fact, sometimes seen in the Cirriform cloud level	Modern Meteorology (English). Picture by Ley	Turreted Stratus (Ley)	S. Tur. 3

* The halos occasionally seen with this form are probably due to the sheet cir. or cirrus haze behind it. † When in *small* quantities and the crests between the furrows are well separated (more so than in Photo by Riggenbach, No. 139) are said to portend thunderstorms within a very few hours. Letter to M. O. No. 1340/88. ‡ Possibly a lower form of a peculiarly linear type of Sheet Cirrus, seen occasionally, and shown in Hild 2. § Often called Fleecy Cloud. ‖ I have observed these clouds chiefly in Spring or Autumn time, when a South-westerly or Westerly wind has been veering, or about to veer to North-west. "Graupel" has commonly succeeded their appearance.

TABLE—Showing the Classes of Clouds and their Approximate Altitude above the Mean Sea Level, the Names of Varieties, with a Description of each, and a Reference to the Pictures which have been considered in classifying them, together with some Abbreviations suggested for use in Registers. *Continued.*

Names proposed for each Variety.	Description of Main Characteristics.	Pictures and Photos used in preparing Classification.	Names hitherto applied to each Variety.	Abbreviations for use in Registers.
	Class 4. Highest (or Cirriform) Clouds—20,000 feet and more.			
Continuous Stratus 4	Very thin uniform film, looking like a very high milky haze. Causing halos, and called by some authorities Cirrus-haze	None available. The pictures in Cloud Atlas 5 is very similar, but is lower, too dense for true Cirrus-haze, and has no halo round sun		S. Con. 4
Detached Stratus 4	Sheet of cloud consisting of numerous small rounded masses or cloudlets, very similar to those of S. Det. 3, but thinner, so that when light is passing through them no portion appears to be in shadow. Sometimes called a "Sheep Sky"	Hild. 4; Cloud Atlas 6; Singer 2; Aber. Riggenbach 214	Cirro cumulus (Howard and most later writers); "true high cirro cumulus (Ley)	S. Det. 4
Rippled Stratus 4	Having same bearing, with regard to Detached Stratus 4, as Rippled Stratus 3 has to Detached Stratus 3. Sheet consisting of thin elongated cloudlets arranged closely together in parallel rows. Commonly appearing in patches, but sometimes covering the whole sky	Singer 8; Riggenbach 109	? Cirro Stratus	S. Rip. 4
Cirriform Stratus (Sheet) 4	Sheet of cloud having ill-defined filamentary texture—the filaments coalescing more or less in forming the sheet—and producing a linear appearance, either of right or curved and complex lines	Hild. 2 and 3	Cirrus or Cirro Stratus (not well defined)	S. Cir. (S) 4
Cirriform Stratus (Filamentary) 4	Cloud appearing like bunches of hair (hence the term "Mare's Tails") or like well-combed hemp, delicate feathers, or very delicate sea weed. Filaments sharply defined and separated clearly from one another, sometimes reticulated. Usually in patches—this is the highest of all varieties	No satisfactory picture, but Riggenbach 53 is a fair specimen; and Dan.	Cirrus	S. Cir. (F) 4

The following abbreviations have been used in Column 3:—"Hild"=Hildebrandsson's essay "Classification des Nuages," 1879, and the numbers following, to the No. o f the plate referred to. "Aber"=Abercromby's Photographs in the possession of the Meteorological Office. "Ley"=various publications by the Rev. W. C. Ley, M.A. "Cloud Atlas"=the Cloud Atlas issued in 1890, by Drs. Hildebrandsson, Köppen, and Neumayer (based on the Hildebrandsson-Abercromby proposals). "Singer"= the Cloud forms proposed by Dr. Karl Singer in 1892. "Dan"= Danish Meteorological Observations, 1880.

decrease steadily in vertical measurement, as compared with horizontal, the higher they are found. Thus if we start with the massive *cumulo-nimbus*, whose base is often very low, the next form in which we meet with this type is the *cumulus* pure and simple, where the vertical height from base to summit is obviously less, and lastly, we find it in the complex *strato-cumulus*, where the vertical measurement is still smaller. All these are in Class 2, and at higher levels no true cumuliform clouds appear.

Another illustration is found in the *detached stratus* variety. We have its lowest form in the fog-banks (Class 1) already referred to, their vertical, as compared with their horizontal, measurementbeing large; they appear again in Class 2, as the *strato-cumulus* just mentioned, and here their height is reduced; they are next found in Class 3 as *Detached Stratus* 3, with very slight vertical measurement; and lastly, in the cirriform level as *Detached Stratus* 4 (the true *cirro-cumulus*), so thin that the sun shines through them, without throwing any portion of them into shadow.

3. I think it a much better plan in classifying clouds to begin in the region from which cloud matter (the raw material) is derived, and in which neighbourhood the forms of the clouds observed are less well defined than they are in any other stratum, and to proceed thence in an upward direction, till we reach the region where all clouds cease to exist, than to begin above and move in the opposite direction.

4. That it is desirable to have a classification so arranged that new varieties when identified may find their proper place in it without in any way interfering with those already placed, must be evident to all.

By good cloud observations alone can we at present get any direct knowledge of the movements of the higher wind currents over level country. Once let us be possessed of good cloud observations, taken by a fairly numerous body of observers scattered over the country, observing simultaneously, and using the same terms when referring to identical forms, there must of necessity be a development of our knowledge of the atmospheric circulation both in cyclonic and anticyclonic systems, which cannot fail to be of the utmost value to meteorologists, and to the world at large.

Before closing, there are one or two minor matters which deserve to be mentioned.

First, it is evident that considerable experience is required by observers before they can say whether any of the continuous stratus form which they may be looking at belong to Class 2 or Class 3, and in arriving at a decision it will be necessary to consider how the overcast condition has come about—*i.e.* what stratum of clouds was contributing to its development.

Secondly. The position of the cloud with regard to the observer must be carefully considered if its true form is to be registered—the appearance of many forms when viewed from beneath being essentially different from those of the same character when lying away near the horizon.

Lastly. It would appear from what has here been said, that for cloud-work observers should be carefully trained before their records can be used for any but the roughest investigations. In fact it is becoming more and

more necessary that Meteorological Observers should be educated for their work much more thoroughly than they are, so that the accumulation of material of indifferent quality may give place to the collection of information which may be relied on by investigators.

DISCUSSION.

Rev. W. Clement Ley, in a note to the Secretary, said:—

"I shall touch very lightly upon two or three of the numerous points which suggest themselves to me in connection with some of the remarks, and with the classification laid before us by my friend Mr. Gaster. A feeling of admiration for the courage and of sympathy with the difficulties of any one who attempts to classify phenomena presenting a large number of natural cross-divisions must possess the minds of those who have devoted time to this special study; and of this feeling I certainly have a full share.

"In some papers read, and in discussions held before this Society, simplicity has been regarded as the *summa felicitas* to be aimed at in cloud classification. I am glad on grounds previously given that the author recognises in this paper as many as about twenty sub-divisions of clouds, and thinks them worthy of distinctive consideration. It is by no means as an unfriendly critic that I would point out a special feature in this paper, a feature which the author appears to recognise in speaking of the varieties in each class as they 'ordinarily appear over the northern half of Europe,' and which is implied in some of the cloud names which he suggests. The feature is this, that the nomenclature appears to be, in some sense of the words, *non-international* and *non-scientific*. By a non-international system I mean one in which English words do duty side by side with classical ones; and by non-scientific I here mean a classification which does not rest on differences of physical process, such as simple radiation from the earth and from dust particles, convection currents, the over-lapping of currents differing in velocity, direction, or both, the adiabatic effects of condensation and of congelation on the forms of cloud. It is held by many that the whole subject of the physics of the atmosphere has not yet been sufficiently investigated to admit of its application to the classification of cloud forms. This is an opinion which I do not share, but which claims the greatest respect. But, in any case, this paper will not have its provisional value impaired by the absence of an attempt in the direction above mentioned.

"One or two words on some of the varieties mentioned in the paper.

"I think the conclusions drawn as to the vertical thickness of clouds simply from the obscuration of sunlight are hazardous, and that Mr. Gaster has over-rated the vertical thickness of the sheet of high fog (continuous stratus No. 1). On the other hand, with regard to cumulo-nimbus—I take special interest in a compound cloud which I first provisionally christened cumulo-nimbus,—I must not blame Mr. Gaster for following the majority of observers in treating the altitude of this cloud as only 16,000 feet (supposing this to be taken as the level of the summits, and not of the middle portions of many cumulo-nimbi). I further think it a mistake to speak of the summits of these clouds as breaking up into 'false cirrus.' In a large number of cases the summits of heat thunder-storms are eventually left in the sky in the form of the loftiest cirri, while in others they rise in their greatest development as mighty domes of ice-mist above the level of the surrounding cirrus of a summer day.

"I must also make a remark on Mr. Gaster's 'mammato-cumulus.' Having been the originator of the word 'mammatus,' and of the prefix 'mammato,' I think it necessary to remark here that as associated with thunderstorms the sac-shaped, festooned or tubercled appearance belongs to the under surface of the entirely frozen and extended summits of cumulo-nimbi, generally when approaching their final stage. On the other hand, as associated with gales, the dependent sacs form the under surface of the sheet of ice cloud, formed in an analogous manner, but on a more extensive scale, which frequently overlaps the front of an advancing cyclonic disturbance.

"I think that the author has done wisely in adhering to a great extent to Luke Howard's general system. Perhaps it is a misfortune that we should be

restricted in the nomenclature of clouds to a language so meagre in terms applicable to physical phenomena as the Latin language, and cannot avail ourselves, as in many branches of science, of Greek nouns and derivatives. The author has partly escaped this difficulty, but, as I have already indicated, at some expense. If his classification will stand the strain of being adapted to international use, I think there would be no difficulty in giving Latin equivalents for the English terms. And I may be permitted to remind the Society that an author, several times referred to in this paper, has stated, as a result of travels in many parts of the globe, that cloud forms are the same all over the world, but that they possess a different language, or a different interpretation in different parts of our planet."

Mr. BAYARD said that there appeared to be too many systems of cloud classifications and varieties already in existence, and consequently there was a tendency to create confusion in cloud observations. Our first need was a representative set of cloud pictures arranged under Howard's nomenclature. If such a guide could be obtained, the cloud observations of the future would be more useful and satisfactory.

Admiral MACLEAR said that Mr. Gaster's table of cloud forms and their characteristics would doubtless prove useful to the student of meteorology, but it was hardly likely to be of service to the average meteorological observer. He had had considerable experience in teaching various grades of seamen to make intelligent meteorological observations, and had found it a good plan to keep to the simple names, cirrus, cumulus, stratus, with suitable qualifying words, such as ragged, torn, &c., in order to more fully describe any peculiarities which might be seen. He thought it would not be advisable to put such a classification as that proposed by Mr. Gaster into the hands of a large proportion of observers, as there would be the temptation to lose time in carefully comparing and matching the clouds seen with the description given, and before such a process could be accomplished, the form of the cloud would probably have undergone a complete change, and the observers would have to commence again.

Mr. SYMONS said that one difficulty which suggested itself in connection with Mr. Gaster's proposed cloud classification was, how were ordinary observers to determine the altitude of the clouds?

Mr. ELLIS, whilst fully sensible of the value of attempts to improve the nomenclature of clouds, had hitherto felt that it would be difficult readily to teach the newer systems to observers so as to ensure confidence in the descriptions that they might give.

Dr. BUCHAN said that the experience of the capabilities of observers which he had gained during his annual tours of inspection had shown him that usually certain forms of cloud were well known and readily identified, while in regard to other forms, some doubt and difference of opinion appeared to exist. He thought it would be better that the construction of a system of cloud classification should be a process of slow growth, as an increased knowledge of the process of atmospheric changes might lead to a better understanding of the conditions under which certain cloud structures were formed. He had frequently noticed the formation of clouds on the western hills of Scotland, and he believed that such formations entirely depended upon the barometric conditions of the air. The formation of cumulus clouds on a hot summer day was probably due to unequal heating of the earth's surface giving rise to upward air currents of various degrees of temperature and humidity, the conflict of which currents was exhibited by their condensation into visible vapour in the form of clouds.

THE PRESIDENT (Dr. Williams) said that, like Mr. Symons, he was in doubt as to how observers were to determine the altitude of the clouds. He considered it would be better to confine the terms used in a cloud classification to one language, and preferred such simple terms as those employed by Admiral Maclear in teaching seamen. While commending the scientific classification of clouds, he regretted their disappearance from the field of the imagination, to which their beautiful and ever-varying forms furnished a perpetual stimulus.

Mr. GASTER said, in reply, that he was well pleased with the discussion which had taken place, though he wished Mr. Ley and Captain Wilson-Barker could have been present. He pointed out that the altitudes he had inserted in the paper were given merely for information; the observer was not required to

consider them at all unless he chose. He considered that the various forms assumed by the clouds within those different limits of altitude which he had quoted were sufficiently distinct to enable observers with pictures of them to register at once which variety it was they were observing, while the altitudes would enable the subsequent investigator to plot very approximately the movements of the currents in which the clouds were floating. He did not think he had attached too much importance to the height (from base to summit) of the high fogs, but deferred greatly to Mr. Ley on such subjects. The other matters referred to in the discussion should have his careful attention.

FIFTEEN YEARS' FOGS IN THE BRITISH ISLANDS, 1876-1890.

By ROBERT H. SCOTT, M.A., F.R.S.

[Received May 25th.—Read June 21st, 1893.]

As the subject of Fogs is forcing itself on general attention, especially in London, it has occurred to me that perhaps it might be of interest to the Society if I were to lay before it an account of the fogs recorded in these islands of late years.

It is impossible to obtain any information from our records as to the duration of fogs. All that can be done is to extract from the schedules of observation the number of times fog is entered.

Here we are at once met with a difficulty, for the three phenomena of "fog," "mist," and "haze" all produce obscurity of the atmosphere, and there is, as yet, no clear distinction between them. Is the difference between them only one of degree, fog being the superlative? or is there any generic difference between the three things?

This difficulty at once struck me when I proceeded to compare the telegraphic reports with the entries made at the stations of the second order. More than one practised observer at a Second Order Station entered every case of obscure atmosphere as "m"; as regards the telegraphic stations one reporter frequently sends up a statement of "misty rain," which, of course, goes down as "m" in the reports; while another habitually enters "mist" or "haze" on almost every day of the month, even when the sun is burning the card of his sunshine recorder.

It finally appeared necessary to restrict the inquiry to the telegraphic reports, and, in order to introduce uniformity into the figures, to adopt the two observations, at 8 a.m. and 6 p.m., which appear in the *Daily Weather Report*, as representing the day. If fog was reported at either of these two epochs the day was set down as a fog day, but no distinction has been drawn between the days at which "f" is set down for both observations and those on which it appears for only one.

The fifteen years 1876 to 1890 were taken, and the commencement was

made with 1876 because the full reports for 6 p.m. were first issued in the *Daily Weather Reports* on April 1st, 1875. All the stations have been taken which have observed continuously through the whole interval, and those only, with two exceptions. Nottingham was replaced by Loughborough in 1882, and Dover by Dungeness in 1884. In these two cases the records have been held to be continuous.

The Table giving for each station and for each month in each year the number of fogs reported during the entire period is not printed, but the monthly totals of fogs at all stations are given in Table I., which show the variations from year to year.

TABLE I.—MONTHLY TOTALS OF FOGS AT ALL STATIONS, 1876–1890.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1876	85	54	12	39	11	21	24	39	49	54	79	36
1877	55	27	43	20	15	24	32	40	34	77	44	69
1878	69	87	9	73	24	21	24	32	39	54	72	98
1879	45	66	57	31	28	52	26	37	47	76	46	90
1880	87	49	74	14	7	32	17	43	60	52	40	51
1881	113	57	46	35	27	26	30	25	54	45	60	81
1882	80	64	47	28	37	26	23	29	42	69	39	115
1883	53	27	31	26	10	22	17	23	59	58	53	61
1884	45	27	27	21	28	25	54	43	63	40	56	26
1885	43	31	35	15	8	27	32	21	28	32	50	70
1886	43	85	66	20	18	35	20	56	29	68	58	46
1887	72	45	66	14	16	38	14	17	28	34	54	36
1888	120	18	23	25	25	49	16	35	75	76	31	84
1889	85	25	28	13	76	28	12	19	46	55	84	87
1890	38	56	23	20	43	31	18	10	32	45	53	70
Sums of 15 years	1033	718	587	394	373	457	359	469	685	835	819	1020

Table II. (p. 281) gives the monthly totals for each station for the whole 15 years. These were plotted on 12 maps, so as to show the geographical distribution of the fogs to the meeting.

If we take the winter first, as being the foggiest season, the greatest number of fog observations is in the Thames valley and at Yarmouth; the *six* months total, October to March, being for London 680, for Yarmouth 610, and for Oxford 508. Ardrossan comes next to these stations with 485, but as regards this last named place the amount of fog is very local. The two stations nearest to Ardrossan are Leith and Donaghadee, and the total for the same six months is, for the former 260, and for the latter only 87.

In the summer half year, in the months from April to September inclusive, the fog prevalence attains a local maximum in two different localities—at Scilly, St. Ann's Head, and Roche's Point in the south-west, and at Sumburgh Head and Wick in the north. These are evidently sea fogs accompanying warm weather. North Shields reports a considerable amount of fog throughout the year, possibly owing to its being on a river.

It has appeared to be of interest to see what relationship exists between

TABLE II.—MONTHLY TOTALS OF FOGS, 1876–1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Sumburgh Head	5	1	9	8	23	30	44	47	18	11	5	1
Stornoway	3	6	8	6	6	9	11	7	10	4	5	4
Wick	14	5	6	17	39	36	32	40	17	10	5	3
Nairn	6	1	5	7	6	16	7	8	14	2	3	2
Aberdeen	10	6	9	10	11	16	15	11	10	5	4	1
Leith	36	33	23	14	10	8	9	10	34	47	69	52
North Shields	45	33	33	21	29	21	9	28	54	54	49	68
York	73	32	16	8	4	0	0	8	23	51	62	69
Nottingham	57	34	34	9	9	4	2	18	52	72	47	62
Ardrossan	97	80	61	54	28	31	14	39	62	82	69	96
Donaghadee	10	2	3	3	2	14	13	8	17	11	8	2
Liverpool (Bidston)	50	34	22	8	5	7	4	16	22	45	45	51
Holyhead	35	37	24	23	18	19	17	16	18	23	9	23
Valencia	9	9	2	7	4	1	3	12	8	15	6	5
Roche's Point	24	14	17	15	17	37	22	30	23	15	16	25
Pembroke (St. Ann's Head)	45	40	41	25	41	55	54	38	41	15	25	26
Scilly	38	35	33	24	48	77	64	66	48	17	23	23
Hurst Castle	44	29	34	18	13	22	9	13	29	18	19	40
Dover	36	38	29	25	16	30	15	19	6	27	21	48
London	131	84	73	32	16	7	7	10	82	132	117	143
Oxford	103	58	42	15	3	1	2	10	61	87	101	116
Cambridge	18	10	4	3	1	0	0	3	4	13	14	26
Yarmouth	144	97	59	42	24	16	6	12	32	79	97	134
Totals	1033	718	587	394	373	457	359	469	685	835	819	1020

fogs and calm weather. Any Londoner knows that the first breath of wind blows his fog away. In order to test this relationship I have entered to each observation of fog the wind, force and direction, at the time. The direction did not appear to deserve further notice, as in very light winds the direction is notoriously doubtful.

Table III. gives the results of this analysis, all the stations being thrown together. It will be seen from the last column what an overwhelming preponderance comes out for the lightest winds. "Calm" with Forces 1 and 2 take 77·9 per cent. of all the observations. It is undeniable that captains at times report fog, with "the air as thick as pea soup," and with a gale of wind, but still I am of opinion that fog is not the proper entry.

TABLE III.—RELATION OF FOG TO FORCE OF WIND, ALL STATIONS.

Years.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	Totals.	Per Centages.
Calm	101	125	106	143	124	136	141	90	92	53	88	79	105	108	80	1571	20·3
Force 1	186	163	270	188	203	214	222	184	208	154	207	194	215	217	172	2997	38·7
" 2	86	95	118	117	105	98	92	81	82	89	104	79	107	119	92	1464	18·9
" 3	61	41	59	75	50	92	72	46	38	47	65	41	73	64	37	861	11·1
" 4	44	25	28	41	35	33	50	22	21	31	53	29	50	26	33	521	6·7
" 5	14	13	11	18	2	17	14	9	10	14	20	6	18	16	19	201	2·6
" 6	8	15	10	18	7	7	5	6	2	4	3	4	6	7	4	106	1·3
" 7	1	3	0	1	0	2	1	1	1	0	3	1	2	1	1	18	·3
" 8	0	0	0	0	0	0	2	0	1	0	1	0	0	0	0	4	
Totals	502	480	602	601	526	599	599	439	455	392	544	433	576	558	438	7743	99·9

In order to further test this matter all the cases of entry of fog with strong winds, *i.e.* with forces 6, 7, and 8, Beaufort Scale, 128 in number, have been extracted, and to each has been put down a notice of the weather at the time. Out of the number 56 were reported on days on which not less than 0·10 inch of rain was recorded, so that here we have thick mists set down as fog. Eleven cases occurred after heavy rain, half an inch or more in the preceding 24 hours. In these instances, apparently the entry of fog instead of mist was incorrect. Fifteen were cases occurring either immediately before or during a gale, and these are evidently thick mist.

We have therefore in 15 years, out of nearly 8,000 observations, a residue of only 46 reasonably dry fogs occurring with strong winds.

In the face of what has just been said, I submit that little harm would result if the observers were directed to put down "m" instead of "f" whenever the force of wind reaches 8 of the Beaufort Scale. This would give a basis for a definition of fog, that it only occurs with anticyclones, or, at least, under anticyclonic conditions.

An interesting fact as to the distribution of the high wind fogs is that they are almost entirely confined to the entrance of the English and the Bristol Channels. Scilly claims 48 of them, St. Ann's Head 31, Hurst Castle 11, Holyhead and Roche's Point 7 each. The total of these figures is 105 out of 128, leaving only 24 for all the remaining stations.

In conclusion, it may be interesting to say a word or two about London fogs. In much of the recent utterances about fog, the term has been taken as synonymous with smoke. I have myself seen an advertisement of a fire grate which described it as "non-fog-producing," and throughout Dr. Oliver's recent *Report on the effects of Urban Fog upon Cultivated Plants*, the actions complained of are those of various substances produced by the combustion of coal, and not of those of the peculiar form of condensed aqueous vapour which constitutes true fog.

It seems to be generally assumed, without any attempt to cite figures, that fogs in London are increasing in frequency and in severity. The fog entries for London have been taken out in order to test this idea, and are exhibited in Table IV. It will be seen that neither in any monthly nor in the annual curve is there any trace of a regular increase. Individual foggy months can easily be picked out from the table. As to the annual totals, 1886 was the foggiest year, with 80 days, and 1887 came next, with 68. All that can be said is that taking three lustral periods, of five years each, the last of these 1886-90 comes out markedly the worst, the successive totals being 262, 250, and 322.

In my own opinion the alleged increased of fog, especially in the south-western district of London, is attributable to the extension of building during the last quarter of a century. This has increased the number of chimneys, and whereas twenty years ago the fogs which reached the Chelsea Nursery Gardens were apparently innocent country fogs, they have of late years assumed the urban character with all its deleterious attributes, owing to the fact that they have had more copious stores of smoke to contaminate them.

TABLE IV.—FOGS IN LONDON, 1876–90.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
1876	10	3	1	2	0	0	0	0	6	5	10	1	38
1877	5	1	4	1	3	0	0	0	6	11	6	4	41
1878	6	8	0	2	1	0	0	1	6	10	9	12	55
1879	6	3	9	3	2	1	1	0	9	7	9	16	66
1880	14	6	6	3	1	0	1	1	7	10	4	9	62
1881	11	5	3	2	0	1	0	0	7	6	3	6	44
1882	9	12	4	3	1	0	0	0	6	8	4	13	60
1883	9	4	4	2	0	0	0	1	6	8	6	8	48
1884	5	5	6	2	0	0	1	0	4	3	14	4	44
1885	8	4	9	3	1	0	1	0	4	7	7	10	54
1886	8	12	9	3	3	3	1	4	4	12	10	11	80
1887	12	9	11	2	1	1	2	1	4	9	11	5	68
1888	8	3	0	2	0	1	0	0	7	15	6	14	56
1889	15	1	4	1	3	0	0	2	1	11	12	13	63
1890	5	8	3	1	0	0	0	0	5	10	6	17	55
Totals	131	84	73	32	16	7	7	10	82	132	117	143	834

According to Dr. Oliver, what does mischief to plants is the amount of foreign substances suspended in the fog, and not the fog itself.

DISCUSSION.

Admiral MACLEAR said it was necessary to emphasise the difference between mist and fog. Mr. Scott's statement that fog was driven away by wind was confirmed by the experience of all sailors, but mist or haze would remain with a high wind. As an example of this he quoted the South-east Monsoon, which, although dry, always brought thick weather, at times almost as thick as a fog, and the stronger the wind the more dense it became, whilst with the North-west Monsoon, which brought the rain, the atmosphere was clear. He inquired whether elevation had any effect upon the prevalence of fog in the cases quoted. St. Ann's Head, where fogs were rather prevalent, was high, and perhaps at Scilly, also a foggy place, the observations were probably made in an elevated situation. [He adds that a fog generally had a defined limit, like a cloud, and sometimes could be seen like a wall, while mist has no defined boundary, and haze may be due to dust.]

Hon. ROLLO RUSSELL said that he would like to know whether any precise definitions of mist, fog or haze could be found anywhere, as he had never been able to meet with any. He had hitherto been in the habit of considering mist as thin fog, but so far as he could gather from Mr. Scott's paper, a mist was rather like a fine or small rain. It was important that observers should be able to make a clear distinction between mist and fog, and he hoped that this paper would lead to some definite results in this direction. Under existing conditions the observations seemed to be greatly confused, some observers reporting mist as fog, while others seldom recorded an observation of fog, and in fact individual observers appeared to have widely different ways of viewing the same phenomena. The number of fogs at Yarmouth was particularly noticeable, and seemed to require some explanation. He had some time ago extracted the records of fog as given in the *Daily Weather Report* for certain years comprised within the period 1872-1882, and had been rather surprised to find that fogs at Yarmouth were so numerous. The averages for the places selected during the years for which the observations had been utilised were as follows:—Yarmouth 12·2 %, London 13·5 %, Aberdeen 2 %, Dover 6 %, Holyhead 6·2 %, Scilly 10 %, Oxford 10·5 %, Liverpool 6·6 %, Valencia 2·4 %, Hurst Castle 3·2 %, and Leith 5·8 %.

He was glad that Mr. Scott had separated summer from winter fogs, for it was important to make a distinction between the prevalence of fog in these two divisions of the year, there being a large number of summer fogs at seaside towns, but very few fogs in winter. He did not quite concur with Mr. Scott as to wet mists occurring after heavy rain, for he had seen a good many mists after such rains which could not be distinguished from dry fogs. He considered that there was after all some truth in the name "non-fog-producing" as applied to the fire grate referred to in the paper, as it was well known that the London atmosphere was often very clear in the early morning, but soon after the fires in the houses were lighted fog was formed, and frequently the outlying suburbs were clear when the more central districts were enveloped in fog. Doubtless fogs could be greatly mitigated in large cities if anthracite coal was much more commonly burned. Mr. Scott's figures certainly seemed to show that the number and intensity of fogs had not greatly increased during recent years, but he (Mr. Russell) was inclined to think that in some parts of the town the density of the fogs had become considerably greater.

THE PRESIDENT (Dr. Williams) remarked that it was somewhat difficult to separate land fogs from sea fogs; but if Table II. in the paper was carefully examined and the inland places compared with those at the seaside, some such distinction was possible, as it was then clearly shown that fogs prevailed chiefly in winter at inland stations, while at seaside stations the summer was the period of greatest fog prevalence. The large amount of fog at seaside towns, as, for example, Yarmouth, seemed difficult to account for, although perhaps in the case of that town, the general flatness of the surrounding country, and the Broads in the immediate vicinity, as well as its situation at the mouth of the Yare, might all tend to produce a foggy condition of the atmosphere there. The marked difference in fog prevalence between places so similarly situated as Oxford and Cambridge was rather puzzling, the Cambridge observer recording but 96 days of fog during the 15 years, while at Oxford fog was experienced on as many as 599 days. Possibly the floods which frequently occurred in the neighbourhood of Oxford might to some extent give rise to conditions suitable for the formation of fog. When on boating excursions up the River Thames he had been much interested in watching the fog rise in the evening after a hot day, and had particularly noticed that its upper limit was almost invariably from 3 to 4 feet above the ground. The influence of wind upon fog prevalence was very clearly shown in the paper, and it would be remembered that during the foggy period which was experienced in the winter of 1890-1, a very calm condition of atmosphere prevailed. In a paper[1] which Mr. Brodie read before the Society, it was stated that Westerly and Southerly winds almost invariably dispersed the fog, while calm weather or very light breezes from North and East were favourable to its persistence. It was always necessary to remember, when speaking of London fog, that it was something very different from what was usually understood by the term fog. Doubtless, if London did not exist, the locality, by reason of its natural peculiarities of situation, would be subject to a considerable amount of fog prevalence, but then it would take the form of a white fog. A "London Fog" is essentially, the result of the addition of the products of combustion, and becomes injurious for two reasons: 1st, on account of the tarry products present which envelop the drops of moisture and thus obstruct evaporation, hence the dryness of a London fog, as shown by the pavement and road, on which there is little condensation of moisture; 2nd, because the amount of carbonic acid in the air is largely increased during its prevalence, owing to the smoky vapour preventing its diffusion. Mr. Scott certainly seemed to have proved that fogs in London are not increasing in frequency, but at the same time they appear to have become blacker and more harmful. When the enormous amount of surface drainage which had been carried out for several years past was considered, it appeared reasonable to expect that fogs in London should be on the decrease rather than otherwise; but the benefits arising from such extensive systems of drainage were probably more than counterbalanced by the increase in the number of fires due to the city's rapid growth, and the consequently more favourable atmospheric conditions for fog production. November had hitherto

[1] *Quarterly Journal*, Vol. XVII., p. 160.

been regarded as the foggiest month of the year; but according to Mr. Scott's figures, December, January and October were the most foggy months.

Mr. Bruce said that Mr. Aitken's theory as to the condensation of vapour on dust particles seemed to form an important feature in the production of fog. London fog was but an exaggeration of a country fog, the increase in density being due to the deposition of the moisture upon the smoke particles suspended in the atmosphere. When at Brighton about a year ago, he had witnessed the effect of the smoke upon a sea fog as it drifted landwards, and had noticed that in the vicinity of the large hotels along the sea front the fog, which was elsewhere of quite an ordinary character, had every appearance of a London fog.

Mr. Brodie said that he could scarcely agree with Mr. Scott's statement that "fog only occurs with anticyclones, or at least under anticyclonic conditions," as a stagnant condition of the air, apart from any consideration of the height of the barometer, was an important element in the production of thick weather. Fogs were always liable to occur in winter time, when the barometric gradient was slight; and although, as a general rule, such conditions were only prevalent with anticyclonic weather, a large number of instances could be cited in which fogs occurred when the type of pressure distribution was distinctly cyclonic. From the fact of a London fog being dispersed by a light breeze, the author of the paper seemed to infer that it was impossible for fog to prevail anywhere with a wind force exceeding 3 on the Beaufort Scale. It was, however, not at all unusual for the *Daily Weather Report* observers stationed on our south-west coasts to report fog with a wind force of 5, 6, or even 7, and as such occurrences were frequently confirmed by the testimony of three or four observers, acting quite independently, it would be scarcely fair to say that the reports were incorrect. Mr. Scott's proposal that observers should be directed to put down "m" instead of "f" whenever the force of the wind reached 3 of the Beaufort Scale, would be a rather dangerous rule to adopt, and would probably lead to further errors. Fog appeared to be largely a question of the degree of observation of surrounding objects, and it would be a good plan if the inspectors of stations would instruct observers in the method of taking fog observations by means of carefully noting the visibility or obscuration of suitably fixed landmarks. In his (Mr. Brodie's) paper on London Fogs[1] it was shown that there had been a decided increase in the prevalence of fogs within recent years. The present paper appeared to disprove this idea; but it must be remembered that the figures upon which it is based cover a less extended period. It seemed highly probable that if the values in Table IV. of Mr. Scott's paper could be carried back over the lustrum 1871-75, the general result would accord more closely with that given in his own paper.

Dr. Marcet said that although there appeared to be a tendency towards an increase in the number of fogs in London, the increase was certainly not nearly so great as might have been expected when the growth of the population was considered. The population of London doubles every fifty years, so that if fog prevalence was in any way influenced by increase in population, fogs should have become much more frequent than formerly. Dr. W. J. Russell had shown how injurious fogs were in preventing the diffusion of poisonous gases, and had ascertained by means of many experiments that the amount of carbonic acid in the air of London in a clear atmosphere, "4 parts in 10,000," was much increased in foggy weather, and in a very thick fog might rise to no less than 14 parts in 10,000. He (Dr. Marcet) had made some investigations as to the amount of carbonic acid in the air on plains and on mountain summits, the results of which were given in the *Quarterly Journal*, Vol. XIII., p. 166. He had found that in clear fine weather the amount of carbonic acid was the same at both the high and low stations, but when a cloud formed on the mountain summit round the observer, the carbonic acid within the cloud fell to a marked extent.

Rev. W. C. Ley, in reference to Dr. Williams's remarks concerning the extraordinary differences in fog prevalence at apparently similarly situated stations, said that in the cases of Oxford and Cambridge, the large difference in the number of fogs recorded was perhaps due to the dissimilar positions of the observatories. At Oxford the observatory was located in the low lying meadow

[1] *Quarterly Journal*, Vol. XVIII., p. 40.

land, at a small altitude above the river, and in a position that would be likely to be subject to fog; but at Cambridge the observatory was on relatively higher ground, and further removed from the influence of the river. Fogs were often to be seen over the low ground in the neighbourhood of the Cam, while at the observatory level the air was clear.

Mr. CURTIS said he thought the rejection by Mr. Scott of all observations of "*mist*" would explain some of the peculiar differences in the frequency of fog shown by some of the stations, not very dissimilar in situation, given in Table II. Fog and mist he believed to be exactly the same thing; but no doubt some observers would describe as "mist" the very same phenomenon which another would call "fog," and the differences referred to were no doubt largely due to the preference shown by adjacent observers for the one word or the other. At present no understanding had been arrived at upon the point; and while some men used "mist" as the diminutive of "fog," others did exactly the opposite. Until, therefore, some agreement had been come to as to the use of the words, it would be very unsafe to attach much value to comparisons made between different stations, as was done in Table II. "*Haze*," on the other hand, he considered to be distinct from fog, and he would define it as a slight obscuration of the atmosphere due to the presence of dust. Coming to the second part of the paper, he thought a proper distinction had not been drawn between ordinary fog and the quite different phenomenon known as "London fog," which was peculiar to London and perhaps a few other very large cities. An ordinary fog consisted of water particles; it was experienced with cyclonic as well as with anticyclonic conditions, and, as he had himself experienced, with at any rate a moderate wind as well as in a perfect calm. In rural and seaside districts a fog is white, while in urban districts it becomes more or less dirtied with smoke. But a "London fog," as commonly understood, was a different phenomenon. It almost invariably occurred with anticyclonic conditions, and frequently concurrently with fine bright weather just outside the town limits. It never existed with wind, and a light air was enough to dissipate it. As a rule it was perfectly dry, consisting almost entirely of products of combustion which the still air had caused to accumulate over the city, and which sometimes spread over the town as a dense pall at some height above it, but more generally descended to the ground. As this phenomenon was so entirely distinct from what was usually known as "fog," he thought in any discussion of the subject of fog the two things should be separately treated.

Mr. GASTER said, in passing, that it was curious to notice that the months of January and December are the months of greatest fog prevalence, and yet they are also the most stormy months as well. From the paper and from all observations it appears evident that there are two distinct kinds of obscuration to which the term fog has been hitherto applied,—one which occurs in cold calm weather, when the barometer is high and no rain falls; and another which is associated with warm weather, strong winds, heavy rain and low barometer. Mr. Scott's paper had served a good purpose in directing attention to these two distinct varieties, and the question presented is, "Shall we call one mist and the other fog?" Mr. Gaster then entered into a full explanation of the methods he adopted when making observations of fog or haze at Brixton and Westminster, for the purpose of determining the question of intensity. His experience of London fogs led him to believe that they were mainly anticyclonic, and similar with regard to their origin and primary constitution to the fogs experienced in other parts of the country; but their great intensity and their offensive properties were due to the impurities with which they were impregnated by the gases and soot from the numerous chimneys.

Mr. H. N. DICKSON said that at the Ben Nevis Observatory it was the custom, when fog prevailed, to enter "m" in the register if there was any deposition of moisture or hoar-frost, while in the case of fogs in which there was no deposition the letter "f" was inserted in the daily records. Fogs or mists frequently occurred with strong winds at Ben Nevis, and on such occasions the wind was supposed to dissipate the vapour, but caused it to assume a torn or ragged appearance. At Plymouth it had been his practice to make observations of the visibility of the Eddystone Light (14 miles distant) and of the Breakwater Light (2 miles distant), and from them to estimate the clearness of the atmosphere. If both lights appeared white, "v" was entered, and he had

found that this condition of atmosphere was invariably followed by rain within the subsequent 24 hours. When the Breakwater Light was invisible, it was considered to be foggy or misty, according to the character of the vapour causing the obscuration, the same distinction between fog and mist being made as was the custom at Ben Nevis Observatory.

Mr. Symons considered that a whole evening could be profitably devoted to a discussion upon "fog," and said that he felt it would be a good thing if the Royal Meteorological Society undertook an investigation into the whole subject. Some years ago he proposed and devised a scale for the purpose of measuring the density of fogs, but did not now use it, although he was not prepared to say that such a method would not be a desirable one to follow. The staff at Kew Observatory had also endeavoured to observe fogs by means of a scale, but the plan appeared to have failed. Dr. Cruikshank, of Aberdeen, was the first person to make systematic observations of the degree of visibility, and for a number of years he carefully noted the visibility of various prominent landmarks which were to be seen from his place of observation. He commenced these observations about 1850, but his favoured position and the clearness of the atmosphere made it possible for him to have a considerably wider range of observation than could be attained in any ordinary town, his view including hills 50 miles distant. Mr. Dickson, too, had spoken of making observations of the visibility of the Eddystone Light from Plymouth, and it was perfectly evident that a scale of distances suitable for a district such as Plymouth would be altogether unworkable if adopted for London, as an ordinary observer in London could not hope to see a much greater distance than two miles. He had frequently noticed the enormous difference between the degree of visibility at Camden Town at 7 a.m. and at 9 a.m., the clearness of the atmosphere at the later hour, owing to the lighting of the household fires, being about one-fourth of what it was at 7 a.m. He thought that as the scale for fog measurements was a quantitative one, it did not much signify whether a post with lines of various thicknesses painted thereon was adopted for estimating the intensity of obscuration, or whether observations of prominent objects at known distances were utilised for the purpose. The personal element was revealed to an extraordinary extent in Table II. of Mr. Scott's paper, the figures being strikingly discordant. Changes in observers would also doubtless cause a want of uniformity in the methods of observations. He suggested that it might be interesting to make a comparison between the observations of fog at the lighthouses and lightships round the coasts of the British Isles, and the records at the stations contained in the *Daily Weather Reports*, for as many years as both sets of observations were available. Regarding fogs in Paris, he knew that while wood was the chief fuel the French city enjoyed an almost perfect immunity from yellow fogs, but during recent years, since coal had been more largely consumed, fogs in Paris almost equalled those of London.

Mr. Inwards thought that some account should be taken of the duration of fogs.

Mr. Marriott said that it would be a great aid to better observation of fog if some authoritative definition were arrived at, so that observers could clearly understand what fog was. After reading Mr. Scott's paper, he had referred to several works on meteorology, in order to ascertain how the various authors defined fog, mist and haze, and he found that in most cases the terms fog and mist were used synonymously. The best and most concise definitions were the following:—

Thomson's Introduction to Meteorology.

"When the atmosphere is humid and the temperature falls below the dew-point, the moisture becomes visible in the form of a haze, mist, or fog. These three indicate different degrees of the same phenomenon:—*Haze* when there is merely an obscuration near the surface of the earth. *Mist* when it presents a defined outline, resting on or hovering a few feet above the ground. *Fog* when the humid vesicles are so numerous as to produce a general obscuration in the atmosphere. The fog which most frequently appears towards morning or at nightfall rises much higher than the mist, and has its upper surface generally well defined."

Jenyns' Observations in Meteorology.

"The terms *mist* and *fog* are often used indiscriminately to signify the same phenomena. It may be convenient, however, to restrict the former name to those low, creeping mists which rise but a few feet above the earth, and to apply the latter to mists reaching to a greater elevation, and generally diffused throughout the atmosphere."

THE PRESIDENT (Dr. Williams) remarked that it seemed to be very generally believed that fogs in London were of comparatively recent date, and that in earlier years they were almost unknown. The following extracts from *Evelyn's Diary* appeared to refute this belief:—

"So frightful a nuisance did the smoke become in the time of Charles II., that Evelyn wrote a pamphlet upon it in 1661, which he entitled *Fumifugium, or the Inconvenience of Aer and Smoake of London dissipated.* In this pamphlet he inveighed vehemently against the absurd policy of allowing brewers, dyers, soap boilers and lime burners to pursue their noisome labours among the dwelling houses of the city and suburbs, complaining that the gardens around London would no longer bear any fruit, and cited instances of orchards, as, for example, Lord Bridgewater's in Barbican, and the Marquis of Hertford's in the Strand, that had produced good crops in 1644, the year in which Newcastle-on-Tyne was besieged, because only a very limited quantity of coal was then brought into London. Even the precincts of the Court were invaded at times by clouds of smoke in which the courtiers could barely discern each other, and frequently it invaded the churches, rendering the minister invisible to his congregation. This pestilential smoke corroded the very iron, spoilt the furniture, left its traces on all which it alighted, and so fatally seized on the lungs of all persons, that consumption and diseases of the chest were very common. 'It is this horrid smoake,' wrote Evelyn, 'which obscures our churches and makes our palaces look old, which fouls our clothes, and corrupts the waters, so as the very rains and dews which fall in the several seasons precipitate this impure vapour, which with its black and tenatious quality spots and contaminates whatever is exposed to it.'"—*Social Life in England*, 1660 1690. W. C. SYDNEY.

MR. SCOTT, in reply, said that in his opinion most of the points raised had been answered by other speakers during the progress of the discussion, and it only remained for him to say, concerning Mr. Symons' suggestion, that a comparison should be made between the observations at lighthouses, &c., and those at the *Daily Weather Report* stations, that Dr. Buchan was at present discussing the observations of fog at the Scottish lighthouses, where the duration of fog as well as its existence was noted; and he, Mr. Scott, had learned from him that he had found that the discrepancies between adjacent observers were nearly as great as any shown in the present paper.

UPPER CURRENTS OF AIR OVER THE ARABIAN SEA.

By W. L. DALLAS, F.R.Met.Soc.

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In July, 1892, Dr. Hildebrand Hildebrandsson addressed the author with reference to a paper in the *American Meteorological Journal*, asking if it would be possible to calculate the mean direction of the upper currents above the different parts of India; and incidentally mentioned that it had been resolved by the Meteorological Congress to hold a "Cloud year," when the special form of meteorological observation would take the form of cloud observation and measurement throughout the world.

Observations of the directions of movement of the upper clouds at several of the Indian observatories have been taken for some years past, their means have been calculated and the results will shortly appear in a paper in the *Meteorological Memoirs* by the Meteorological Reporter to the Government of India. This particular field of inquiry having then been already occupied, the author considered that perhaps the knowledge of cloud movement might be advanced by an examination of the observations of the upper clouds over the Arabian Sea and neighbouring portion of the Indian Ocean north of the Equator. He accordingly extracted all the information available in the Indian Meteorological Office relating to this point.

The author was the more disposed to undertake this work owing to the fact that he has a strong leaning towards the heterodox belief that cyclones, in the true meaning of the word, are initiated in the upper currents, are carried along in those currents, and that their appearance in the atmosphere resting on the earth's surface is rather an accidental than a regular phase of their existence. He was originally drawn towards this conclusion by the difficulty which the apostles of surface generation exhibited in explaining, on the one hand, many well known cyclonic phenomena, and, on the other, the absence in many cases of what might reasonably be supposed to be necessary antecedent conditions. The hypothesis that cyclones are formed in the upper atmosphere, and that, under favourable conditions, they work down to the surface atmosphere, and, under unfavourable conditions, retreat again from the surface atmosphere, explains many of the observed peculiarities of cyclone progression; such, for example, as (1) the advance of rainfall over regions which are in the probable path of a progressive cyclone, even though the cyclone itself has, according to our present idea, filled up; (2) the appearance after a short interval of a *second* cyclone in the direct line of advance of a dispersed cyclone; and (3) the hemicyclonic form assumed by a cyclone on touching a coast line. The hypothesis also would explain: (1) the absence of all antecedent irregularities of temperature over the region where the cyclone appears; (2) the fact that extensive heavy pre-

cipitation frequently occurs without the production of a system of depression; and (3) that a condition of extensive practical uniformity of pressure and of great absolute humidity may exist without the production of a cyclone, though obviously such a condition would be precisely the favourable condition under which a cyclone would work down to the surface atmosphere. Moreover no one can have watched a well observed area, such, for example, as the Bay of Bengal, without remarking that while the conditions antecedent to the appearance of a cyclone are uniformity of pressure and light winds, the disturbance which determines the helical form to the wind circulation enters as quite a distinct phenomenon into the observed area. Equally truly is it the case that after a cyclone has "filled up," as it is now the custom to describe the disappearance of a storm, the observatories which lie along a line, which would in all probability have been the future path of the storm had the existence of the storm at the earth's surface been maintained, show signs, in the shape of rainfall and of high winds at the more elevated stations, of the continued existence of the disturbance even though the barometer at the earth's surface may be rising quickly, and the winds at the same level give no evidence of cyclonic circulation. From a consideration of these and other circumstances the conclusion that cyclonic storms are a product of the upper atmosphere is far from being untenable, and on this account the study of the upper currents is one of vital importance.

Practically the only method by which this study can be carried out over a large part of the earth's surface is by observations of the clouds, and unfortunately this is a form of observation which is peculiarly liable to errors. In the first place, in order to ascertain the normal circulation of the upper atmosphere, observations are required when the atmospheric motions are undisturbed. This is obviously the time when clouds are least likely to prevail, while the greater the abnormal disturbance the greater the amount of cloud and of cloud movement. The author has made five voyages between India and Europe. Three of these were undertaken in the fine season, one in June, at the commencement of the monsoon, and one in September, at the close of the monsoon. During the first three voyages hardly a cloud was seen within the Indian region; and in the last two the only clouds visible were the ordinary detached *cumuli*, which were travelling more or less coincidentally with the surface air current. On all occasions the weather was normal and undisturbed, so that the author's experience certainly suggests that, for purposes of ascertaining the normal circulation of the upper currents, clouds, at least in tropical regions, are unlikely to give very satisfactory results. This conclusion is borne out by the observations now discussed.

The observations given on the accompanying charts are the mean directions of movement of upper clouds collected from the logs of ships traversing the Arabian Sea between the years 1858 and 1877. They are divided into four seasons. The first runs from December to February, representing the cold weather: the second from March to May, representing the hot season; the third from June to August, representing the monsoon; and the fourth from

September to November, representing the autumn. On the charts three direction arrows are shown in each case flying with the current. The thin arrows give the mean direction of the wind at the earth's surface at the time observations of the upper clouds were taken; the broken arrows represent the motion of the upper clouds, which include *cirrus*, *cirro-stratus* and *cirro-cumulus;* and the thick arrows give the motion of the pure *cirrus*. The whole expanse of the Arabian Sea has been divided into spaces of 4° square.

December to February.—The broken arrows on fig. 1 show that the upper atmosphere describes a large direct or anticyclonic curve over the Arabian Sea. The clouds move from north-west over the Persian Gulf and the north of the Sea. Between latitudes 12° and 20° the motion is north-

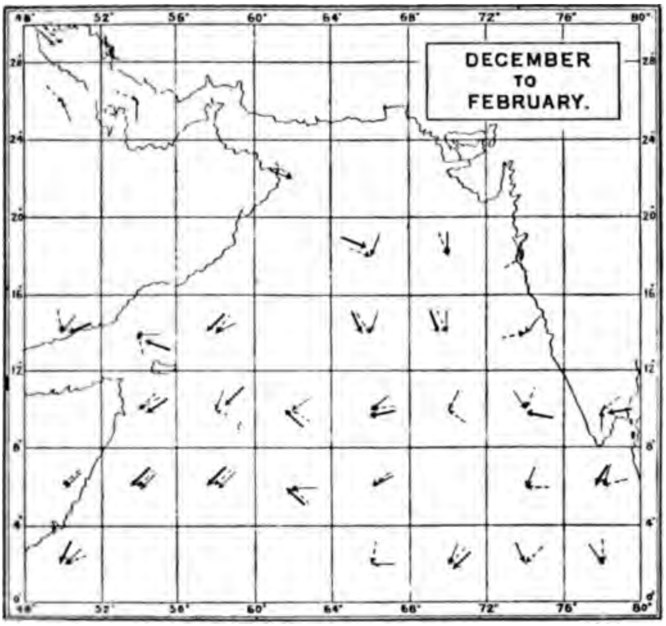


FIG. 1.

north-westerly in the eastern, and north-easterly in the western longitudes, while from latitude 12° southward to the equator, the general direction is from north-east, though with occasional departures to east. This easting is more particularly marked between latitudes 8° and 12°. The thick arrows representing the motion of the true *cirrus* agree very closely with the broken arrows, though there is generally more easting in the former than in the latter.

Table I. gives the mean directions of the surface winds, of the upper clouds and of the pure cirrus clouds for each 4° of latitude for all longitudes. It will be seen from this Table that there prevails a fairly regular system of succession in the various layers of the atmosphere.

TABLE I.—December to February.

Latitudes.	Surface Wind.	Upper Clouds.	Pure Cirrus.
	Motion from		
32°–28°	N 22° 30′ W	N 45° W	N 45° W
28–24	S 12° E	N 56° W	..
24–20	N 67° W	N 45° W	..
20–16	N 2° W	N 69° W	N 67° W
16–12	N 39° E	N 31° W	N 33° E
12– 8	N 39° E	N 81° E	N 82° E
8– 4	N 45° E	N 69° E	N 58° E
4– 0	N 18° E	N 34° E	N 34° E

March to May.—During the period covered by fig. 2 the sun's mean position is about 10° N Lat., and it is probable that the band of greatest heat in the atmosphere lies along this latitude or a little to the northward.

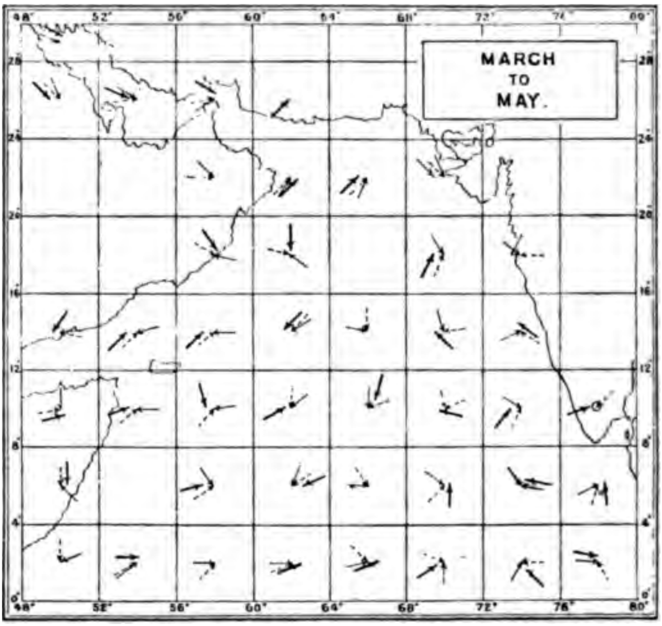


Fig. 2.

The arrows showing the motion of the wind at the earth's surface, of the upper clouds and of the pure cirrus clouds, exhibit great irregularities. Over the Persian Gulf both the upper clouds and the cirrus come away from north-west, as was the case in the previous quarter. This direction is maintained apparently right across Arabia, but over the north of the Arabian Sea (latitude 16° to 24°) the direction of movement of the pairs of arrows shows

a motion from south-west. Between latitudes 12° and 16° the motion, both of the upper clouds and of the pure cirrus, is on the whole from east (east and south-east), but between longitudes 52° and 60° the high and highest clouds come from south-west, while the surface wind is from the eastward. From latitude 12°N., southward to the equator, the main movement of the upper currents is from the south-westward or west-south-westward, though in the eastern half of that region there are several instances of motion from a southerly and south-easterly point. The main features of the circulation appear to be a current from south-west in the south-west of the chart, drawing round into south and south-east in the south-east of the chart, and subsequently into east over the centre, and a north-westerly current drawing into north and north-east, and subsequently into east, over the north and centre of the chart. Table II., constructed in the same manner as Table I., affords some evidence of this circulation, though it is certainly far from conclusive :—

TABLE II.—MARCH TO MAY.

Latitudes.	Surface Wind.	Upper Clouds.	Pure Cirrus.
	Motion from		
32°—28°	N 79° W	N 68° W	N 68° W
28—24	N 66° W	N 82° W	N 56° W
24—20	S 87° W	S 77° W	S 72° W
20—16	N 40° E	S 85° W	N 50° W
16—12	N 41° E	S 87° E	S 47° E
12— 8	N 24° E	N 56° W	S 81° W
8— 4	N 52° W	W	S 27° E
4— 0	S 64° W	S 83° W	S 82° W

June to August.—In the third quarter the sun, during a large part of the time, is well over the northern Tropic; while from the conditions of the land surface the region of Doldrums is probably some little distance to the northward of the Tropic. The arrows (fig. 8) showing the surface movement of the wind are very regular, but the arrows showing the motion of the upper and uppermost clouds are exceedingly irregular. To the northward of latitude 12° N. the motion is generally from north, drawing into north-east and east. Between latitudes 8° and 12° the upper clouds come largely from the eastward, while the pure cirrus comes from south-east, from south-west, and from north-west. From latitude 8° N. southward to the equator the direction of movement both of the upper clouds and of the cirrus is generally from some point between south-west and west, but there occur a few infrequent instances of movement from north-east and north-west. The probable cause of this great irregularity at this season of the year will be referred to later.

Table III. gives the motions of the different strata of the atmosphere, according to the plan adopted in the previous Tables :—

TABLE III.—JUNE TO AUGUST.

Latitudes.	Surface Wind.	Upper Cloud.	Pure Cirrus.
	Motion from		
° °			
32—28	..	..	..
28—24	..	..	..
24—20	N 67° W	N ?	..
20—16	S 64° W	N 7° E	S 59° E
16—12	S 50° W	N 82° E	N 63° E
12— 8	S 50° W	S 45° E	S 54° W
8— 4	S 57° W	S 56° W	S 39° W
4— 0	S 51° W	S 28° W	S 82° W

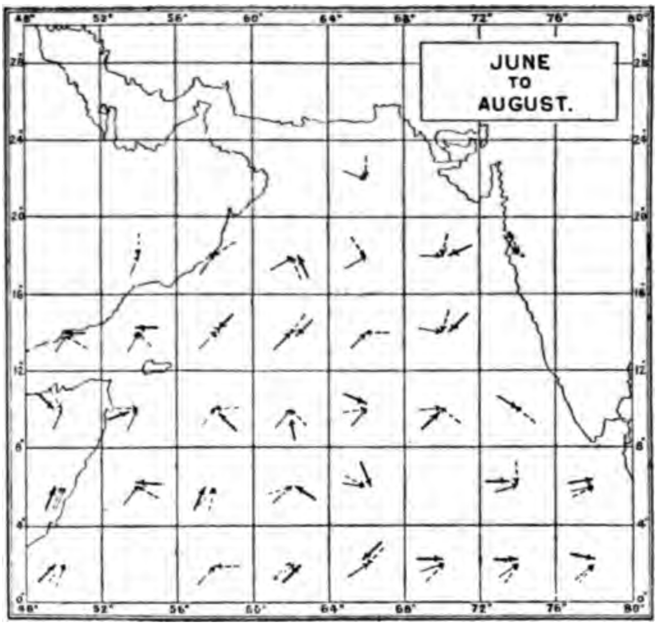


FIG. 3.

September to November.—The mean position of the sun for this peri to the south of the line, but probably from the configuration of the land position of the line of Doldrums is close to the equator. The arrows (fig. surface movement show a motion from south-west over the south-west, a motion from north-west and west over the south-east portions of the sea, a motion from north-west or north-east over the northern portion of the The arrows giving the movements of the upper clouds and of the cirrus s a circulation similar to that prevailing in the first quarter. There is a m ment from north-west over the Persian Gulf, &c., and from north and nc east and even east over the eastern half of the area as we advance southw

Off the Arabian and African coasts the movements are irregular and the upper clouds come at times from north-east, north-west, and west-south-west, while the pure cirrus observations exhibit movements from south, from west, and from north-west.

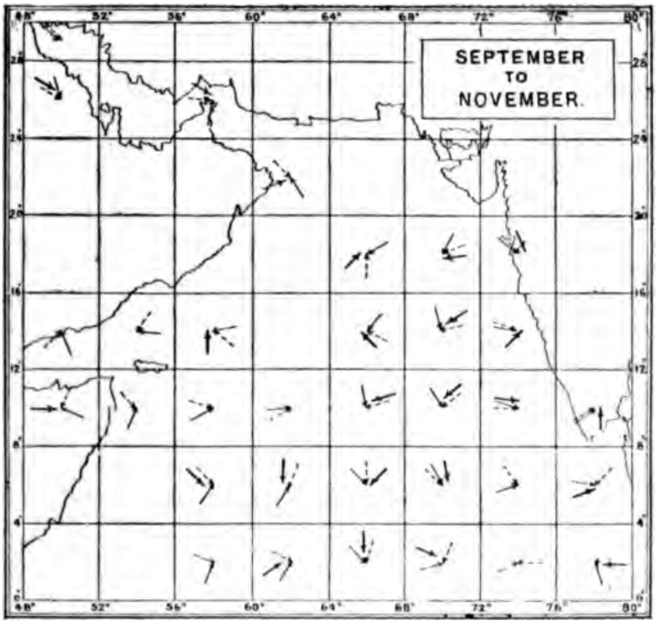


Fig. 4.

Table IV. gives the movements of the different strata in the different latitudes, the resultants showing a fairly close agreement with those giving the movements of the different strata in the first quarter.

TABLE IV.—Sepember to November.

Latitudes.	Surface Wind.	Upper Clouds.	Pure Cirrus.
	Motion from		
° ° 32—28	N 45° W	N 45° W ?	..
28—24	W	N 72° W	N 53° W
24—20	S 34° E	N 45° W	S 67° W
20—16	N 37° E	N 63° E	N 18° W
16—12	N 59° E	S 17° E	S 23° E
12— 8	S 86° W	N 49° W	W
8— 4	S 87° W	N 12° W	N 20° W
4— 0	S 49° W	N 18° E	N 41° W

Let us now consider the general deductions to be drawn from a consideration of these charts and Tables.

In the first place it would appear that the South-east and North-east winds, which are called the " Trades " at the earth's surface, are a marked characteristic of the circulation up to a considerable height, and that this circulation exists even when the surface winds are, owing to surface peculiarities, at variance with this circulation. Thus we have under normal conditions (1) a line of Doldrums, coinciding roughly with the sun's vertical position, and (2) on either side North-easterly and South-easterly winds extending from the surface up to a considerable elevation. These winds produce within the Doldrums a steady current of westerly translation. When, as in the case of monsoon regions, such as India, West Africa, &c., the surface circulation is interrupted and the South-east Trade is turned into the South-west Monsoon, the interruption occurs only in the surface current, the South-east Trades continuing to blow at some considerable elevation, and producing in an upper stratum of the atmosphere with the North-east Trades the westerly translation of the air over the Doldrum region. We have, then, under these conditions a circulation which is approximately as shown in the following rough diagram (fig. 5).

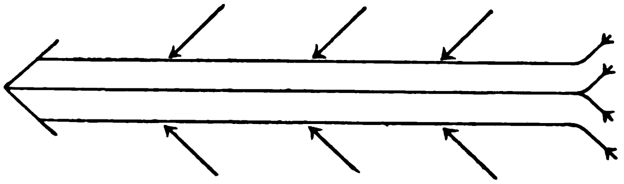


FIG. 5.

This Doldrum region moves, as we know, north and south over Tropical regions. In the case of the Indian region it probably goes as far south as lat. 10° or 12° S., and as far north certainly as the Tropic, and probably considerably further; and on either side, irrespective of the direction of movement of the surface wind, there exist the North-east and South-east winds of the general circulation. As suggested by Prof. Cleveland Abbe a vertical section of the Trades circulation would show that the currents of the Trades and of the return Trades are wedge shaped, being respectively shallowest and deepest in high latitudes. Fig. 6, drawn north and south along a meridian crossing the equator, explains this circulation.

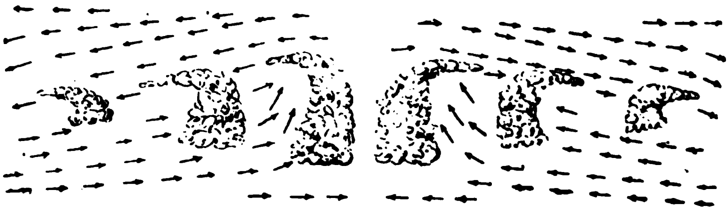


FIG. 6.

According to this conception the South-east and North-east Trades extend to a greater and greater height above the earth's surface on approaching the Doldrum region, while the anti-Trade current draws nearer and nearer to the

earth's surface on approaching the polar limits of the circulation. It becomes evident then that, provided the appearance of the upper clouds occurs at the same elevation above the earth's surface, the clouds would, when formed near the Doldrum region, be borne *towards* that region by the upper strata of the Trades, and when formed far from the Doldrums be carried *from* that region by the anti-Trades. Could we obtain a superficial view of the region shown in vertical section above we should observe a condition of which the illustration (fig. 7) gives a rough approximation, where the thick black arrows show the indraught towards the Doldrum region of westerly translation and the cloud forms show the retrogression of the anti-Trades. If we now apply these principles to the direction arrows shown on the four quarterly charts the following conclusions are deduced.

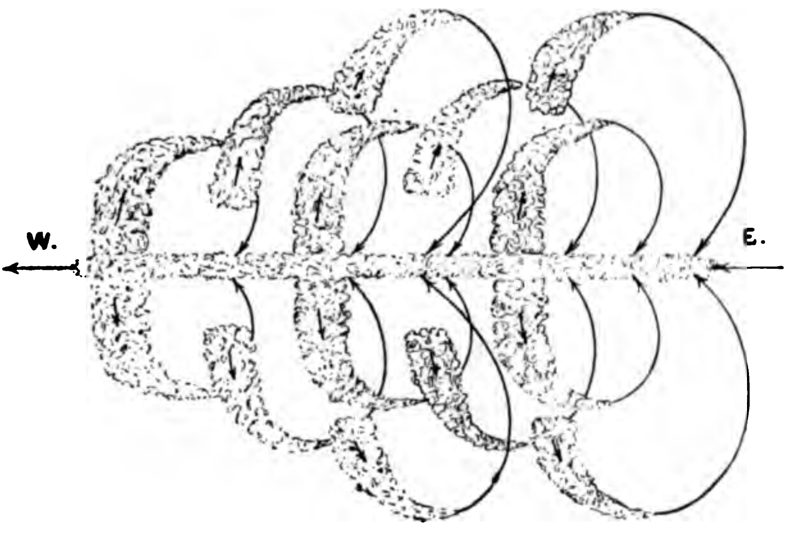


FIG. 7.

In chart 1 the Easterly current of the Doldrums exists on the southern side of the Equator, and the upper and cirrus clouds are carried along in the general Trade wind circulation, except in the north, where they come from North-west, and exist in the anti-Trade current, which, as shown in fig. 8, comes close down to the earth's surface in this portion of the circulation. The upper clouds then, at this season, appear to be all within and carried along by the direct or surface Trade circulation, except those to the north of latitude 20°, which exist in and are borne along by the anti-Trade current as it approaches the earth's surface on the northern limit of the circulation. In chart 2, the current of Westerly translation lies apparently between latitudes 4° and 16°, and the upper clouds to the northward are generally in the lower

half of the Trade circulation, and are carried towards the Doldrum region, though there are several instances of clouds appearing in, and being borne along in, the anti-Trade. The Persian Gulf region is wholly within the anti-Trade current. In chart 3 the Doldrum region is wholly to the northward of the Tropic, and the general movement of the upper and uppermost clouds is along a line agreeing with the thick arrows on the south side of the diagram (fig 7), but there are a few cases in which the clouds exist in the return current and are carried *from* the Doldrum region and towards the polar limits of the circulation. In Chart 4 the line of westerly translation (according to Table IV.) exists between latitudes 12° and 16°, but the movement of the clouds is most irregular, the observations exhibiting, as was the case in chart No. 2, when the sun's position was somewhat similar, great diversity of direction.

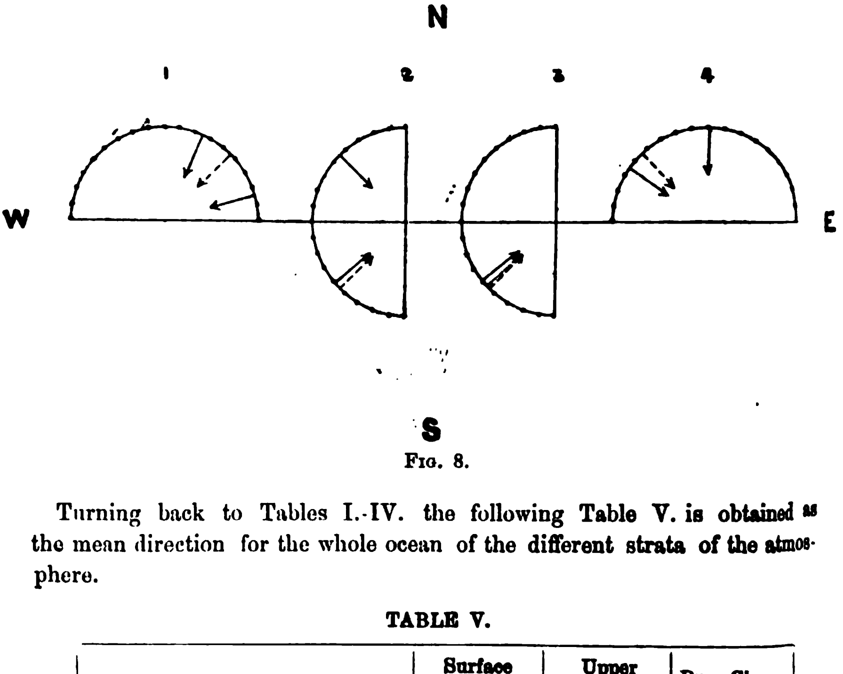


Fig. 8.

Turning back to Tables I.-IV. the following Table V. is obtained as the mean direction for the whole ocean of the different strata of the atmosphere.

TABLE V.

Quarters.	Surface Wind.	Upper Clouds.	Pure Cirrus.
	Motion from		
December to February	N 24° E	N 46° E	N 74° E
March to May	N 45° W	S 45° W	S 49° W
June to August	S 51° W	S 44° W	S 47° W
September to November..........	N 56° W	N 43° W	N 1° E

In the first quarter the direction of the surface wind is from N 24° E, of the upper clouds from N 46° E, and of the pure cirrus from N 74° E; so that

standing with the back to the surface wind the higher strata come more and more from the left hand. In the second quarter the surface wind comes from N 45° W, the upper clouds from S 45° W, and the highest clouds from S 49° W; so that in this quarter the higher strata come more from the right hand. In the third quarter the movement of all the strata is approximately from the same direction, but the higher strata come, as in the previous quarter, from a point to the right hand of the lower stratum. In the last quarter the direction of the surface wind is from N 56° W, of the upper clouds from N 48° W, and of the highest clouds from N 1° E; so that in this case the succession is the same as in the first quarter.

Perhaps the most important conclusion derivable from a consideration of these figures is the evidence afforded that the geographical equator is not the sharp divider which has been commonly supposed. Observations have shown that there exists a regular arrangement in the vertical succession of the upper currents. Thus in the Northern Hemisphere it is the rule that an observer standing with his back to the surface wind, will record the upper currents as coming more and more from his left hand, and in the Southern Hemisphere as coming more and more from his right hand. In the first and fourth quarters this rule holds good, and an observer standing with his back, in the one case turned towards N 24° E, and the other towards N 56° W, would observe the upper currents travelling more and more from a point on his left hand the higher they are; but in the second and third quarters, when the sun is far to the north of the equator, the rule is not maintained, the upper currents coming from a point on his right hand. Hence the conclusion appears to be that the Doldrum region is really the dividing line of the atmospheric circulation, and that the vertical succession of the upper currents appropriate to the Northern or to the Southern Hemisphere, may invade the opposite Hemisphere when the sun's position is so far south or north as to cause the Doldrum region to lie far to the north or south of the equator. Should this conclusion be upheld by further and more exact observations, it is possible that some of the theoretical deductions as to the motions of the atmosphere based on the effects of the earth's rotation may have to undergo modification.

DISCUSSION.

Rev. W. Clement Ley, in a note to the Secretary, said that he failed to understand on what grounds the views of Mr. Dallas could be regarded as "heterodox," since they were to a great extent in accord with those of Dr. Hann and of other eminent meteorologists. Mr. Dallas offered a challenge to those whom he styles "apostles" of the condensation theory of cyclones. It might be worth while to examine his arguments, since these can fairly be taken as specimens of the quasi-scientific reasoning not uncommonly adduced on one side or the other of a highly complex problem. But in the first place it should be remarked that those who maintain that cyclones are principally the effects of condensation occurring in the unstable condition of the atmosphere, in special and well known distributions of pressure, do not attribute the formation of cyclones to condensation actually occurring at the *floor* of the atmosphere, or

suppose the probability of the formation of a cyclone over any locality to be capable of being read off by the use of a hygrometer.

The author seems to advance the following three considerations against the condensation hypothesis. First, the advance of precipitation in the front, *i.e.* in the probable path, of a cyclone is not always followed by the cyclone itself. This is a common phenomenon in many parts of the globe, and as Mr. Dallas goes on presently to say, it is often accompanied by strong winds at elevated mountain stations. He (Mr. Ley) would add that these strong winds are frequently noticeable in layers of cloud between 8,000 and 12,000 feet above sea level. But this consideration surely indicates that cyclones are generated elsewhere near to the earth's surface, and in their advance are propagated *upwards;* it can scarcely be adduced as a proof that they commence aloft and in their progress gradually *descend!*

Secondly, the author adduces on his side the well known phenomenon of the sequence of cyclones along the same or approximately the same path. On the condensation hypothesis this is readily explained. When a progressive cyclone has been established, great quantities of vapour-laden air are carried from a distance towards and partially into the spiral circulation, but the front of the latter in which the great updraught takes place is propagated along its path of progression with sufficient rapidity to leave behind it a large portion of the atmosphere thus set in motion: the movement of the atmosphere thus left behind ceases, but a storage of vapour brought from a long distance remains in it, affording the potential energy necessary for the formation of a new cyclone.

Many tropical cyclones, it is true, advance with a speed which is not one-tenth of that of the winds on the earth's surface which accompany them. One example may be cited. In the very admirable *Daily Weather Charts to illustrate the Tracks of two Cyclones in the Arabian Sea,* published by the authority of the Meteorological Council in 1891, it is observed that on June 8th, 1885, the progress of a cyclone was only 6 miles per honr. But Ferrel observes [*Popular Treatise on the Winds*, 1st ed., p. 303]: "in tropical cyclones the clouds are not driven ahead in advance of the cyclone, but there is enough of easterly current above in the cloud region to carry the clouds eastward to the rear of the cyclone, and consequently there is there 'overcast, damp, and frequently wet weather;'" and the same remark has been made by other writers. According to those who adopt the theory of an upper cloud whirl, the great *Ignotum*, which is supposed to produce such a whirl, has a tendency to act repeatedly over the same place, about which we can of course say nothing.

Thirdly, the author regards the fact that a complete cyclone, on reaching a coast line, frequently becomes a hemi-cyclone, as an indication that the spiral motion belongs properly to the upper layers of the atmosphere. Most students of the subject would suppose that this very fact may be taken as one indication amongst many that it is in the lower layers of the atmosphere rather than in the uppermost, that the energy of a cyclone is primarily active.

He (Mr. Ley) considered that the only real facts which are of value as against the condensation theory are those adduced by Dr. Hann and others to show that on mountains at very considerable elevations, temperatures during cyclonic disturbances are frequently below instead of being above the normal. On the other side, with regard to the hypothesis that cyclones originate as eddies in the highest regions of the atmosphere, and are occasionally propagated downwards to the earth's surface, it need only be stated here, first, that no facts are to be found in support of it, and secondly, that an abundant and constantly recurring set of facts are diametrically opposed to it. It is at least quite certain that in extra tropical latitudes above those barometric depressions which at the earth's surface have closed curves, the cirrus observations prove that in the upper regions of the atmosphere the isobars are hemi-cyclonic, showing an extension in the direction of the tropic of the great polar depressions which in the neighbourhood at least of the great oceans characterise the distribution of pressure at a high level: these hemi-cyclones, be it observed, lagging behind the centres of our deepest cyclones, and frequently not being traceable at all, either over incipient depressions, or over what are popularly termed our shallower systems. It has never been shown that a complete cyclonic gyration in the cirrus regions of the atmosphere has as yet given evidence of its existence over any part of our globe; and even, granting such an imaginary circulation, it has never

been satisfactorily shown how it could, against enormously increasing pressures, work itself down, through friction or viscosity, or by any other of the modes suggested, to the surface of the earth.

The tables and charts accompanying this paper form a contribution to our knowledge of the upper currents of the atmosphere above the Arabian Sea. But in order to arrive at satisfactory conclusions with regard to the general seasonal and, still more, monthly distribution of the movements of the higher atmosphere over this portion of the globe, we certainly require these data to be supplemented by many more. No reference is needful to the difficulty of conducting these observations at sea, for this difficulty has been to a large extent surmounted by the patience of those who have undertaken them.

Considering the extent of the literature now existing with reference to the effect of the earth's rotation upon the movements of the atmosphere, it is perhaps unfortunate that at the end of the paper the author fails to mention what special theoretical conclusions may have, as he thinks, to be modified by his statements.

NOTES ON WINTER.

By ALEX. B. MacDOWALL, M.A., F.R.Met.Soc.

(Abstract.)

[Received April 17th.—Read May 17th, 1893]

The first part of this paper contains an account of various researches on winter, dealing with the relation of our winters to the great pressure systems and the course of the Gulf Stream, the recurrence of severe winters in cycles, the question as to secular change, &c.

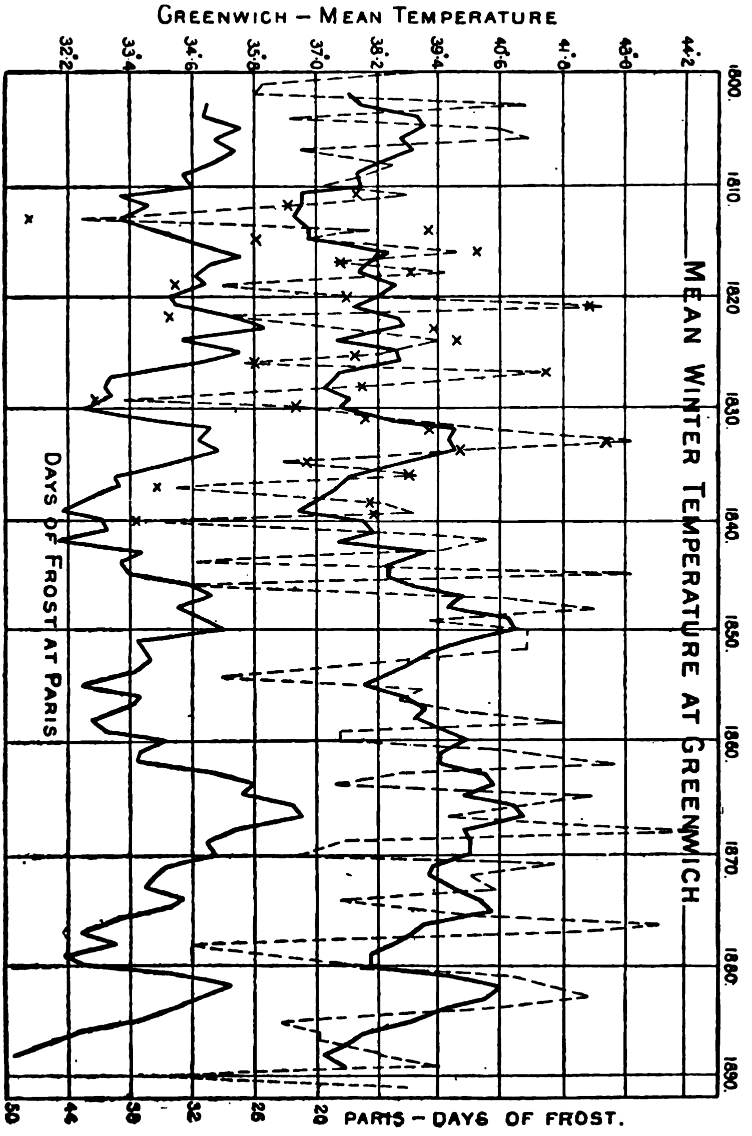
In the latter part the author discusses the question of periodicity in winters at Greenwich and Paris, the relation of summers to winters, &c. He says:—

Let us now, with the aid of a diagram, (p. 252) look at the history of our winters during this century. We take the simple method of the mean temperatures of the three winter months. The position of each winter is indicated by a point, and these points are connected by dotted lines.

The material here used consists of Mr. Ellis's data for Greenwich Observatory, obtained from the photographic records from 1849; and for the period before, Mr. Glaisher's table in the *Philosophical Transactions* for 1850. Some uncertainty of course attaches to the latter, as the figures in that table, as far as 1840, are deduced from observations at Somerset House. For comparison I have given, in the positions indicated by crosses, from 1811 to 1840, values deduced from the table in Mr. Eaton's paper to the Society,[1] which consists of Belville's observations (at different heights) reduced to sea-level. Half a degree has been subtracted from these values to make them comparable with the later Greenwich figures. The values are mostly a little below those of Glaisher.

[1] *Quarterly Journal*, Vol. XIV., p. 15.

Those mean temperatures of winter (from Glaisher and Ellis) have been smoothed by means of five year averages, giving the upper continuous thick curve. For comparison with this I have added a similarly smoothed inverted curve of frost days in Paris in the three winter months (the second continuous curve).



The diminished intensity of our winters, as affirmed by Mr. Glaisher appears in the earlier part of the curve as far as the sixties. We may roughly trace it by the severe winters, 1813,[1] 1829, 1840, 1846, 1854, 1860,

[1] *i.e.* 1813–14, 1829–30, &c.

which form an ascending series (as regards mean temperature). But since the sixties, there would seem to have been a recrudescence of intensity, represented by the descending series 1870, 1878, 1890: and this may perhaps go further in the years to come.

The smoothed curves present an interesting recurrence to which I wish to invite attention. Both the Greenwich and Paris curves attain maxima (high values of mean temperature, and low numbers of frost days, on the five years' average), about the same times, which are in general separated by approximately the same interval. Thus, to take the Paris curve, we have :—

$$\left.\begin{array}{l}1804\text{-}1823 = 19 \text{ years} \\ 1823\text{-}1834 = 11 \quad ,,\end{array}\right\} 30 = 2 \times 15$$

$$\begin{array}{l}1834\text{-}1850 = 16 \quad ,, \\ 1850\text{-}1867 = 17 \quad ,, \\ 1867\text{-}1882 = 15 \quad ,, \\ \hline\end{array}$$

$$78 \div 5 = 15{\cdot}6 \text{ years}$$

What cause, I would ask, can be assigned for this secular variation? Should the recurrence continue, we should expect the next maximum to be reached about 1898.

I propose now to consider for a little, in an empirical way, the relation of November and March to the period between them, the winter proper. Does the character of November afford any clue to that of the coming winter? Is the character of March inferable with any probability from that of winter?

For convenience, we shall class and denote the 92 winters thus :—

Winters with mean temperature 41°·0 and upwards "very mild" (19 cases)
,, ,, ,, ,, between 41°·0 and 38°·9 (the average) "mild" (23)
,, ,, ,, ,, ,, 38°·9 and 37°·0 "cold" (27)
,, ,, ,, ,, 37°·0 and under, "very cold" (23).

Similarly we may divide our Novembers with lines at 41°·0 and 45°·0, getting 25 "very cold" Novembers and 19 "very mild."

Now those 25 "very cold" Novembers were followed by winters thus :—

12 "very cold" + 6 "cold" = 18;
3 "mild" + 4 "very mild" = 7.

And the 19 "very mild" Novembers thus :—

7 "very mild" + 6 "mild" = 13;
4 "cold" + 2 "very cold" = 6.

Thus a "very cold" November is apparently usually followed by a winter colder than the average; and a "very mild" November by a winter milder than the average.

Taking now our 23 "very cold" winters, we find them followed by Marches of this character :

7 "very cold" + 5 "cold" = 12;
7 "mild" + 4 "very mild" = 11.

And the 19 "very mild" winters are followed by Marches thus:—

4 "very cold" + 4 "cold" = 8;
6 "mild" + 5 "very mild" = 11.

From which figures it appears difficult to infer the probable character of March from the character of winter.

The question may now be considered how our winters are related to summers on either side; (summers with mean temperature 62°·0 and upwards being called "very hot" (24 cases), and those 59°·0 and under "very cool" (20 cases)).

Those 28 "very cold" winters were followed by summers thus:—

9 "very cool" + 7 "cool" = 16:
1 "average;"
2 "very hot" and 4 "hot" = 6.

The 19 "very mild" winters were followed by summers thus:—

8 "very hot" + 4 "hot" = 12;
1 "average;"
6 "cold."

Thus a "very cold" winter tends to be followed by a summer cooler than the average: and a "very mild" winter by a summer hotter than the average.

Another view of this influence of winter on summer is afforded by the fact that 20 "very cool" summers were preceded by winters thus:—

9 "very cold" + 7 "cold" = 16;
4 "mild."

Once more, those 28 "very cold" winters were preceded by summers thus:—

6 "very cool" + 8 "cool" = 14;
1 "hot" + 6 "very hot" = 7;
2 "average."

From which it appears also that summers before "very cold" winters have more often been cool than not.

The Paper concludes with a discussion of the number of days with snow at Norwood during a series of years.

DISCUSSION.

Mr. TRIPP said, while everybody recognised the desirability of being able to forecast the character of any approaching season, he greatly questioned whether the periodicity at present appearing from meteorological figures was of much practical use, the average conditions of any period differing so widely from the individual records. No doubt, however, discussion of the subject was useful.

Mr. GASTER said he feared that in preparing such papers as this the authors forgot to take into consideration the character of the systems which produced the different temperatures at different seasons of the year. The anticyclonic system is the one which brings the severest cold in winter, but it is the system which brings the greatest heat in summer; in the one case it allows the earth

to radiate its heat into space, in the other it allows the solar heat to reach the earth freely. The cyclonic systems produce exactly the opposite results, their clouds checking the radiation of heat from the earth in winter, and its advent to the earth in summer. It would appear, therefore, that a careful study of the movements of these systems (and especially of the anticyclonic) would be likely to yield more satisfactory results than the mere indications of the thermometer, even when observed over a wide area.

Dr. BUCHAN considered that the value of the paper would have been greatly enhanced if some definition of the terms "cold," "mild," &c., had been given. The winter had been taken to embrace the months of December, January and February, but it often happened that the character of the weather in each of these months was widely different. In a discussion of meteorological observations made in Scotland during the years 1764-1892, and published in the *Journal* of the Scottish Meteorological Society, he had found that during the first fifteen years of this period there was a succession of extraordinarily mild Decembers and cold Januaries and Februaries, but for a considerable number of years subsequent this condition of things was reversed, the months of December being very cold, and the Januaries and Februaries mild. A mild winter was simply and solely due to cyclones passing north of our islands, while a cold winter was the effect of the cyclonic systems passing to the south of the British Isles. Only a knowledge of the laws which govern the motions and paths of these pressure systems would enable us to successfully predict coming seasons. In October 1878 the surface water of the Atlantic Ocean between these islands and New York was 4° above the average, and consequently a great amount of moisture must have been evaporated into the atmosphere. The ungenial weather of the year 1879 was doubtless well remembered by almost everybody, and it appeared that its wet and sunless character was the result of the excess of moisture poured into the air from the ocean to the west of our islands. In fact for fourteen months following the abnormal temperature of the Atlantic in October, the air temperature over the British Isles never rose to the average.

Mr. HARRIES pointed out that we required no better proof of the futility of attempting to predict the seasons in the manner suggested in this paper than the fact that (even without going as far back as the Shepherd of Banbury), although the method has been repeatedly discussed, and from every point of view, since Kirwan's investigation of the evidence of sequency in the records of the 118 years from 1677 to 1789, the question is now, after a century's research, exactly where it was before the days of Kirwan. The conclusions of the author of the present paper show the impracticability of the sequency theory, for the results of his discussion are, practically, that a cold winter ought to be followed by a cold summer, and a cold summer should precede a cold winter, therefore we are not entitled to any warm seasons, "which is absurd."

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

May 17th, 1893.

Ordinary Meeting.

C. Theodore Williams, M.A., M.D., President, in the Chair.

The President presented a Lantern and Apparatus for use at the Society's Meetings in the illustration of papers. The thanks of the Society were given to the President for this most useful gift.

The thanks of the Society were also given to Mr. B. C. Wainwright for his courtesy in lending his Optical Lantern for the Society's Meetings whenever it had been required.

Hugh Robert Mill, D.Sc., F.R.S.E., 1 Savile Row, W., was balloted for and duly elected a Fellow of the Society.

The following Papers were read:—

"Mean Maximum and Minimum Temperature of the Air on each day of the year, at the Royal Observatory, Greenwich, on the average of the fifty years 1841 to 1890." By William Ellis, F.R.A.S. (p. 211.)

"Suggestions, from a practical point of view, for a new Classification of Cloud Forms." By Frederic Gaster, F.R.Met.Soc. (p. 218.)

"Notes on Winter." By Alex. B. MacDowall, M.A., F.R.Met.Soc. (p. 251.)

June 21st, 1893.

Ordinary Meeting.

C. Theodore Williams, M.A., M.D., President, in the Chair.

The following Papers were read:—

"Fifteen Years' Fogs in the British Islands, 1876-1890." By Robert H. Scott, M.A., F.R.S. (p. 229.)

"Upper Currents of Air over the Arabian Sea." By W. L. Dallas, F.R.Met.Soc. (p. 289.)

Mr. E. D. Archibald, M.A., F.R.Met.Soc., also gave an Address on "Australian Climate and Weather."

CORRESPONDENCE AND NOTES.

Remarkable Sunrise and Rainbow.—Mr. G. E. Hackford, of Boston, sends the following account of a curious appearance of the sky which he observed in the early morning of August 10th. He says: "The sun was rising, and threw an awful yellow glare across to the west, where a storm, or more correctly three storms, had been brightening up the sky with lightning all the night, but about 4.45 a.m. the storm got nearer, and it began to rain very sharply, causing a most weird appearance in the sky. There was a perfect rainbow, and all the yellow in the sky was concentrated within the arc, leaving the outside grey, whilst across all the lightning flashed almost incessantly. This lasted for about ten minutes, when the sun was no doubt covered with clouds, for the rainbow disappeared together with all the yellow in the sky, leaving it grey blue. The storm then drifted north."

Ribbon-like Flashes of Lightning.—In John Pointer's *Rational account of the Weather*, 1783, there is a curious observation showing that he had observed several flashes of lightning following the same path, and he says: "The reason of all the flashes of lightning darting in the same tract is the rarify'd air caused by the first flash."

Life and Work on Ben Nevis.—The Directors of this Observatory have published a *Guide to Ben Nevis*, which is intended to be not merely for the use of the ordinary tourist in ascending Ben Nevis, but also to meet the wishes of a large number of those interested in the work of the Observatory. This little book gives an account of the origin and history of the Observatory, and some of the results derived from the observations and investigations carried on there. The ascent of Ben Nevis during the open season is very easy, as the Directors have made a safe bridle-path 6 feet wide, with gradients nowhere exceeding one in five.

Since May 1884 the observations have comprised a complete set of readings of all the instruments, outside as well as inside the Observatory, at every hour, by night as well as day. The day of twenty-four hours is divided into watches, of eight hours at night and of four during the day. Thus there is always at least one of the observers keeping watch over the weather, and going out punctually at each hour to read the various instruments and make notes. The actual observation takes only from five to ten minutes, but during the remainder of the time there is plenty to do in reducing and filling up the daily records, checking the results, and drawing up daily and monthly averages of the readings of each instrument.

During the months of February and March it is not uncommon to have South-easterly gales blowing for three or four days continuously, at the rate of from 80 to 100 miles an hour; but under these circumstances the hill-top is usually swept clear at once of all loose snow, and a hard surface of rough ice left, which is not touched by the wind, and on which good footing may be got. At first, when the surface was icy and the wind very strong, the observers used to go out roped together, but experience has shown that even in the most violent gusts safety may always be had by lying down, and the rope is seldom used except when it is necessary to go to very exposed places. For the ordinary observations a guide line for use at night in case of the lantern being blown out is all that is required. In steady winds the angle at which the observer leans in order to keep his footing becomes a valuable factor in estimating the wind force. The storms of early winter—November and December—usually bring a thaw and heavy rain, which, though very disagreeable, does not interrupt the usual course of observing; the most unpleasant weather is when it rains while the temperature is still below freezing. The rain then freezes as it falls, and everything gets covered with hard ice, which may increase in thickness indefinitely, the only limit being the time that these conditions continue. On one occasion it lasted for two days, and the ice was more than a foot thick both on the ground and on the windward side of all projections. This deposit of ice or snow on all exposed surfaces is one of the chief difficulties connected with the working of the instruments of the Observatory: it occurs whenever there is fog or mist on the summit.

During summer, or when the temperature is above the freezing point, the fog soaks everything exposed to it. All the instruments outside, and indeed all exposed surfaces, steam with moisture, even though there may be no rain actually falling. In winter, when the temperature is below freezing, the effect of the fog is to cover everything with long feathery masses of crystalline snow. It seems that as the fog is driven across the hill-top by the wind, and brushes against any obstruction, the moisture in it condenses in minute crystalline specks of snow or hoar frost; these accumulate until long cone-shaped crystals are formed, pointing to windward, which grow by continual accretion till they break off by their own weight. These crystals sometimes grow till they form a solid massive pillar about 3 feet in diameter, the nucleus of the whole being a simple wooden post some 6 ins. by 3 in section. This is usually the result of several days' growth, during which time the wind shifts so as to deposit crystals from all sides on the post; but even when care is taken to keep the exposed object as clear as possible, it is impossible to wholly prevent their formation. During dense fog they will often grow at the rate of fully 2 feet a day. This growth rapidly chokes the louvres of the thermometer screen; if the temperature is low the crystals are loose and easily brushed off; but if near the freezing point, even without the objectionable rain mentioned above, the crystals are hard and icy and adhere firmly, needing to be chipped off. This difficulty with the thermometer screen has been overcome by using duplicate screens. When the one in use gets badly choked, no attempt is made to clear it, but it is taken in bodily and a fresh screen with other thermometers inside is put out. The screens are placed, in winter time, on a high stand shaped like a ladder, so that the instruments can be put stage by stage higher up as the snow gets deeper, and may always be about 4 feet above the surface of the snow. In summer, when the top is clear of snow, an ordinary Stevenson screen is used. In these screens are four thermometers—dry bulb, wet bulb, maximum and minimum. The dry and wet are read hourly, the maximum and minimum once a day at 9 p.m.

Thunderstorms are rare on Ben Nevis; on the average there are only about half-a-dozen in the year, mostly in autumn and winter; and there have been intervals of as long as two years without either thunder or lightning being observed. Most of the ordinary summer thunderstorms seem to pass below the hill top, and even thunder is not heard. But when a storm does pass over the summit it is a most unpleasant experience. The cloud is seen approaching with lightning flashing from it; it then envelops the hill-top, during which time no lightning is seen, but rain or snow falls heavily—as much as one-third of an inch in ten minutes has been recorded: and then, as the cloud moves off, a discharge takes place, not merely from the cloud but from all large metallic bodies in the Observatory; a brilliant flash springs out from the stoves, and a sharp crack like a pistol shot is heard. Some of the observers have received shocks under these circumstances, but no serious harm has been inflicted. The most severe of these storms was in January 1890; one of the observers was almost knocked down when sitting writing, and the telegraph wire was fused, and all communication stopped for five days. This is the only occasion in eight years that the telegraph wire has failed, a very different record from that of High Level Observatories situated in regions where summer thunderstorms are felt at greater heights.

Another electrical phenomenon sometimes seen is the continuous discharge from elevated points known as St. Elmo's Fire. It usually appears like little jets of flame on the lightning-rod, anemometers, etc., but in the more brilliant displays every post and chimney is tipped with fire, and sparks glimmer on the observer's hat, pencil, or fingers. It is always accompanied by a peculiar hissing or buzzing noise, and almost invariably by a heavy fall of soft hail or conical shaped snow. It is most frequent in winter, but it may sometimes be observed in stormy weather in summer. The optical meteorological phenomena observed on Ben Nevis are of great interest and beauty.

Hail.—The Hon. Rollo Russell has just published a book *On Hail*, in which he has collected together various descriptions of hailstorms and hailstones, and observations of temperature, clouds, and winds at great altitudes, as well as the theories of many authorities on the formation of hail. After describing the development of a hailstorm he sets forth the conclusions which he has arrived at from a discussion of the data in the book. Mr. Russell's conclusions are to the following effect:—

The clouds in which large hail has its origin are commonly at a great height —between 15,000 and 40,000 feet, or higher. These clouds are the result chiefly of expansion and refrigeration of warm humid air, of the sudden mixture of masses of air greatly differing in temperature and vapour tension, and of free radiation. The nucleus of a hailstone consists of a snow flake, pellet, or spicule, which falls from the uppermost cloud. The snow flake, pellet, or spicule, is electrified, as a result of condensation, and as it falls attaches to itself particles of ice and globules of water below the freezing point, the particles arranging themselves commonly in a stellate form or concentrically around the nucleus. The variety of form of the primitive kernel is great, and consequently hailstones of many different shapes may be met with.

Large hail may not infrequently be caused by snow flakes or soft hail falling into dense cold cloud in the central part of a tornado, and being whirled upwards so as to traverse the thickness of the cloud more than once.

The small and about equal-sized particles of an ordinary dense cloud appear to be incapable of falling in rain or snow, unless within certain limits electrically excited, and unless pervaded by drops, snow flakes, or hail kernels, proceeding from a higher level, where electricity is more potent. Thus the necessity, as a rule, for two or more layers of cloud for the precipitation of rain and snow becomes intelligible.

Showers and hailstorms are generally due in the first place to ascending masses of vaporous air coming in contact with drier, colder, and more highly electrified air, where, with strong radiation, precipitation is determined, and to the great reduction of temperature in an ascending and expanding column of air. The low temperature, the electric attraction, the rapidly proceeding condensation of vapour, and the congelation of water on ice-particles, contribute to make the nucleus harder and more compact than snow, and it therefore falls rapidly. Its temperature in the first few thousand feet of descent may be estimated at 10° to 50° below the freezing point. As the hailstone falls, the temperature of the air surrounding it naturally increases, but through the greater part of its fall is below normal. The dew-point of each successive layer encountered is above the temperature of the hailstone, so that deposition takes place with great rapidity.

The greater part of the cloud through which the hailstone falls consists of a dense mass of water particles below the freezing point, but unfrozen. The water particles attach themselves firmly to the hailstone owing to impact, to electric attraction of the larger and more highly electrified mass, to contact with ice at a low temperature while themselves below the freezing point, to congelation and regelation so resulting, and to cold produced by rapid partial evaporation. The latent heat set free by solidification is not sufficient to prevent the rapid growth of a hailstone passing through cold moist air.

The depth of dense cloud through which a hailstone falls varies very much, but in the greatest storms may be estimated at from 10,000 to 30,000 feet; but part of this depth is usually occupied by clear spaces which may be supersaturated, or in a condition to precipitate heavily on solid objects. If these spaces are below the freezing point, vapour may be condensed as a clear zone upon the hailstone. The more opaque zones are composed of particles of cloud deposited as water globules and ice crystals, or as very minute rain drops frozen on contact. The average duration of fall of a large hailstone may be from 5 to 10 minutes from the time of formation of a small pellet.

Turreted cumulus is especially indicative of hailstorm weather, and forms a very distinct phenomenon. The condition of atmosphere denoted by it may extend over very wide areas, although hailstorms only occur at a few localities within those areas. The localities most affected by hailstorms are those in which temperature and humidity are often high, and above which, at heights between 15,000 and 40,000 feet, the temperature is often very low, and generally below the freezing point when warm weather prevails on the earth's surface; moreover, the slopes of certain mountains against which hot winds blow, places where strong up currents are likely to be developed in a moist or very hot air, and places subject to eddies by the conformation of neighbouring mountains, are especially liable to falls of hail. Hot plains and low hills near high mountains are often more visited by hailstorms than the mountains themselves, no doubt owing to the greater heating of the low ground and the more sudden irruption of warm into cold, or cold into warm strata.

The cold spell which often follows a hailstorm is not owing to the fall of hail, but to the descent of a block of cold air. For the cold is felt not only where the hail has fallen, but in other neighbouring localities, and after slight hailstorms or an appearance of hailclouds a similar reduction of temperature occurs.

The barometer is generally little affected by hailstorms.

The clearness of the air sometimes occurring before a hailstorm is caused by smoke and dust being carried upwards towards the cloud, and the clearness which always follows a hailstorm is caused by the descent of fresh pure air from high levels. Mixture of greatly differing air currents is not in general alone sufficient to produce heavy precipitation, as has been shown by Hann, Pernter, von Bezold, and others. But rapid condensation, and consequent production of hail and rain by other agencies, often follows from the mixture of moist, warm, with cold, currents, moving from different directions.

The severity of a hailstorm is roughly proportional to the difference of temperature between mixing currents, the suddenness of mixture, the moisture of the warm current, and the suddenness with which it is elevated either to a great height, or into the vortex of a tornado.

London Fog, 1813.—In the discussion on Mr. Scott's Paper in the present number (p. 233) attention is called to the increasing severity of what is called London fog. These fogs, however, are no new things, as will be seen from the following extract from the *Annals of Philosophy*, February 1814, p. 154 :—

"Between Monday the 27th of December 1813, and Sunday the 2nd of January 1814, a most extraordinary fog prevailed in London, and seems to have extended a great many miles round in every direction. It was frequently so thick that it was impossible to see across the street, candles were burnt in most of the shops and counting-houses all day long. This fog condensed upon the grass, the trees, and every wooden or iron railings. The grass was covered with a coating of snow (condensed fog) at least half-an-inch thick. Below the trees in St. James's Park there lay a bed of snow an inch thick at least, which had fallen from them. In London the thickness of the fog was still farther increased by the smoke of the city ; so much so, that it produced a very sensible effect on the eyes, and the coal tar varnish might be distinctly perceived by the smell. But at a distance from town, though there was no smoke, the fog was very thick. Not a breath of wind was perceptible during the whole week."

Gale in the Bahamas, August 26th-27th, 1893.—In a despatch to the Colonial Office, Mr. H. Jackson, the Administrator of the Bahamas, states :— The cyclone which devastated the south-east coast of the United States on August 28th was also severely felt on the 26th and 27th in the northern portion of the Island of Abaco, though only slightly in the remainder of this colony. The centre of the cyclone appears to have travelled in a north-westerly direction, and to have passed a considerable distance to the north of the Bahamas, throughout the whole of which the wind blew a violent gale, doing considerable damage to the local shipping and destroying the standing crops, and breaking and uprooting trees. Two of the contract mail schooners were driven ashore, but will be got off without much damage, and many other vessels shared the same fate, while some were beached for safety.

Except in the Island of Abaco there has been little or no damage to property, save to the wharves, which have suffered severely. This immunity may be attributed to the long warning given by the barometer, which enabled people to haul up their boats and secure the buildings. In Nassau the barometer fell about eight-tenths below normal, reaching 29·34 ins. on the afternoon of the 26th, when the anemometer marked the force of the gale as 37 miles an hour, but no damage was done here except to trees. The only loss of life reported is from Clarence Town, Long Island, where a father and son who were out fishing were swept out to sea, and must have been drowned, as the boat was afterwards recovered bottom upwards.

At Abaco, however, the gale was far more severe, and the barometer at Green Turtle Cay, the principal settlement, fell to 28·50 ins., while the tide rose 8 feet above the usual level and flooded the settlement. The resident justice reports 48 houses destroyed, or about a fourth of the whole number, and many others

badly damaged, and the whole settlement heaped with the *débris* of these houses and of the ruined wharves, together with broken boats and rubbish of every description washed up by the sea. At Hope Town, the settlement next in importance, the damage has been about equal, whilst March Harbour and Coheroker Sound, both on the main island, have also suffered heavily, having wharves and buildings destroyed, roads washed away, and all the crops ruined. It is fortunate indeed that there has been so little loss of life, as some of the small inhabited Cays were so completely submerged that even the sweet potatoes and other root crops which usually escape were washed out of the ground and carried away by the sea, and the people left absolutely destitute, without food, shelter, or even water, the shallow wells having been filled and spoilt by the overflow of the waves. At the small settlement of Sand Banks, a small bay twelve miles north of Green Turtle Cay, there was left at the close of the hurricane absolutely no food of any description among the 150 inhabitants, and no means of getting any.

Shanghai Meteorological Society.—This Society, which has just issued its first Annual Report, was founded in 1892. The aim of the Society is "to further by study and observations meteorological knowledge in general, but especially the knowledge of the maritime meteorology of Eastern Asia, such as the normal meteorological conditions prevailing along the coast, the laws of storms, typhoons, etc." The President is the Rev. F. S. Chevalier, S.J., Director of the Zi-Ka-Wei Observatory. The Report contains a brief account of the principal typhoons of the year 1892; a proposal for the adoption of the international nomenclature of clouds, as recommended by Hildebrandsson and Abercromby; and a paper on the frequency of fogs along the northern coast of China.

Diseases in relation to Atmospheric Conditions.—Dr. D. Hardie, of Brisbane, has endeavoured to establish a connection between the condition of the weather as represented by the various meteorological readings with a few of the more common diseases. He has taken the mortality statistics and meteorological observations in Queensland for the five years 1887-1891, and made careful comparison between them. His conclusions are as follows:—

1.—That in summer, with high barometric pressure, mean temperature, mean daily range of temperature, and absolute range of temperature, and low relative humidity, rainfall, number of rainy days, and amount of cloud, high mortality may be expected from typhoid fever, diarrhœa and dysentery, as well as a somewhat higher death rate from pneumonia and phthisis, while that from diphtheria will be unusually low. 2.—That should the above conditions obtain also during the previous months of spring, the mortality in summer from typhoid fever, diarrhœa and dysentery will be all the higher, while that from diphtheria will be similarly reduced. 3.—That in summer, with low barometric pressure, mean temperature, mean daily range of temperature, and absolute range of temperature, and high relative humidity, rainfall, number of rainy days, and amount of cloud, the mortality from typhoid fever, diarrhœa and dysentery is low, while that from diphtheria and whooping cough is equally high. 4.—That should these conditions prevail during the former months of spring, the death rate in summer from typhoid, diarrhœa and dysentery will be still further reduced, while that from diphtheria and whooping cough will be still further increased. 5.—That should these conditions be decidedly well marked in summer—as in a time of flood—the mortality from diphtheria will probably be high during the months of autumn. 6.—That the condition of the atmosphere, therefore, during the last few months of the year provides a fair means of estimating the class of disease that may be expected during the early months of the following year, and similarly also its condition in summer provides a fair means of estimating the class of disease likely to be prevalent the following autumn. 7.—That in autumn and winter, with high barometric pressure, low mean temperature, high mean range of temperature, and absolute range of temperature, and low relative humidity, rainfall, number of rainy days, and amount of cloud, an increased mortality may be expected from respiratory diseases, together with a low death rate from diphtheria, croup, and whooping cough. 8.—That in winter, with low barometric pressure, mean temperature, mean range of temperature, and absolute range of temperature, and high relative humidity, rainfall, number of rainy days, and amount of cloud, the mortality from respiratory diseases will be reduced, and

that from diphtheria will be increased. 9.—That in winter, with low barometric pressure, high mean temperature, low mean range of temperature, and absolute range of temperature, and high relative humidity, rainfall, number of rainy days, and amount of cloud, the mortality from respiratory diseases will be reduced still further, while whooping cough, on the other hand, will possibly become prevalent during the following months of spring.

RECENT PUBLICATIONS.

American Meteorological Journal. **A monthly review of Meteorology. May-September. Vol. X. Nos. 1 to 8.**

The principal articles are :—Meteorology as the physics of the atmosphere : by Prof. W. von Bezold (21 pp.).—Charts of storm frequency: by Prof. Cleveland Abbe (2 pp.).—Coloured cloudy condensation as depending on air temperature and dust contents, with a view to dust counting : by Prof. C. Barus (22 pp.).—Six and seven day weather periodicities : by H. H. Clayton (10 pp.).—New England Meteorological Society (17 pp.). This gives an account of the proceedings at the meeting held on April 22nd, at Cambridge, Mass., when papers were read on the relation of Solar Spots to Terrestrial Anticyclones ; a new series of isabnormal temperature charts based on Buchan's isothermal charts ; the relation of the prevailing winds to the physical features of Missouri ; Proposed subjects for correlated study by State Weather Services ; Notice of H. F. Blanford ; and oscillations of lakes.—The Sling Psychrometer in a balloon : by Prof. H. A. Hazen (2 pp.).—Recent foreign studies of thunderstorms : by R. de C. Ward (22 pp.) The author gives a summary of the principal publications on thunderstorms in Germany and France from 1887 to the end of 1892.—Mountains as storm breeders : by T. H. Harris (5 pp.).—The Climate of the eastern portion of the coast district of Texas in its relation to the cultivation of fruits and vegetables : by J. H. Clive (12 pp.).—The movements of the air at all heights in cyclones and anti-cyclones as shown by the cloud and wind records at Blue Hill : by H. H. Clayton (8 pp.).—Weather forecasts and scientific investigation : by M. W. Harrington (3 pp.).—The periodic terms in meteorology due to the rotation of the sun on its axis : by Prof. F. H. Bigelow (15 pp.).

Annuaire Société Météorologique de France. November 1892-February 1893. 4to.

The principal articles are :—Resumé des Observations météorologiques faites à Ayata (Sahara Algerien) Octobre 1891—Decembre 1892 (2 pp.). The maximum temperature recorded during this period was 121°·3 on July 18th, and the minimum 31°·2 on January 18th.—Problèmes relatifs à la circulation générale de l'atmosphère : par H. Lasne (19 pp.).—Resumé des observations centralisées par le Service hydrométrique du bassin de la Seine pendant l'année 1891 : par M. Babinet (30 pp.).

British Rainfall 1892. **On the Distribution of Rain over the British Isles during the year 1892 as observed at nearly 3,000 stations in Great Britain and Ireland, with articles upon various branches of rainfall work. Compiled by G. J. Symons, F.R.S., and H. Sowerby Wallis, F.R.Met.Soc. 245 pp. and five plates. 8vo. 1893.**

The rainfall was exceptionally small over the Severn Watershed, South Wales, and in the South-east of Ireland, the deficiency being more than 30 per cent. of the average. Over England and Wales generally the rainfall was about 10 per cent. below the average, while in Scotland and Ireland the rainfall was about the average. The largest rainfall recorded at any station in the British Isles was 172·20 ins. at the Stye, Cumberland, and the least rainfall 16·25 ins. at Tewkesbury, Gloucester. In addition to the usual information respecting the rainfall of the year, this work also contains articles on the evaporation from a water surface at Lawrence, Massachusetts ; Evaporation Experiments at Southampton Waterworks and at Camden Square ; and comparison of German and English rain gauges.

Ciel et Terre. Revue populaire d'Astronomie, de Météorologie et de physique du Globe. July-September 1893. Nos. 9-14. 8vo.

Among the articles appearing in these numbers are:—Les extrêmes de froid supportés par l'homme (4 pp.).—L'ozone et la prévision du temps: par Père Bruno, S.J. (4 pp.).—Les variations de la temperature à l'intèrieur d'un arbre: par W. Prinz (12 pp.).—Le climat de Groenland autrefois et aujourd'hui (9 pp.).—Sur la variation diurne barométrique à Paris d'après vingt années d'observations par appareils enregistreurs: par C. Lagrange (2 pp.).—La protection contre la foudre: par A. McAdie (10 pp.).

Investigations of the New England Meteorological Society for the year 1891. Reprinted from the annals of the Astronomical Observatory of Harvard College. Vol. XXXI. Part 2. 4to. 88 pp. and 4 plates, 1893.

This contains a report by Mr. R. de C. Ward on the thunderstorms in New England during the years 1886 and 1887. The Society carried on the investigation of thunderstorms with the aid of a grant from the Bache fund of the National Academy of Sciences, and also with assistance from the Signal Service in clerical work, &c. The results of the investigations of the two years agree in most particulars. There is a difference, however, in the relation of the cyclonic centres and the positions of the thunderstorms, for in 1886, 60 per cent. occurred in the southern or south-western quadrant of cyclones central north of New England, while in 1887 the majority of the storms occurred in the south-eastern quadrant or under anticyclonic conditions. Only 40 per cent. of the 1887 summer thunderstorms occurred in the southern part of distinct cyclonic storms; while in 1886 the number was 70 per cent. Mr. Ward points out that the prediction of thunderstorms for New England is a difficult task, and that no very definite rules can yet be laid down. A few general conclusions with regard to the probable occurrence or non-occurrence of local storms based on the weather and pressure conditions on the morning weather map are the only results of this investigation as far as prediction is concerned. The average rate of movement of the thunderstorms during the two years was between 30 and 35 miles an hour.

Meteorologische Zeitschrift. Redigirt von Dr. J. Hann und Dr. G. Hellmann. May-August 1893. 4to.

The principal articles are:—Regenwahrscheinlichleit und Bewölkung in den Vereinigten Statten von Nordamerika: von W. Köppen (8 pp.). This is a discussion of the periodicity of rain and cloud over the whole of the United States. The diagrams given for various districts, five in number, generally agree with the following principles:—1. The annual maxima of rain probability appears when any district is warmer than adjacent districts, and the minima when it is colder. 2. Of two adjacent districts in which the annual variation of temperature is very different, that with great amplitude of variation has summer rains, while that with small amplitude has winter rains. It must, however, be admitted that these principles are modified by many secondary agencies.—Zur Dynamik der Atmosphäre: von M. Möller (21 pp.). This is a theoretical paper dealing with the causes of ascent and descent of air, and deserves careful study from those who deal with the difficult problems of atmospheric motions.—Klimatische Wirkung des Waldes auf seine Umgebung: von E. Ebermayer (14 pp.). This is an analysis of the results obtained, especially in Austria and in Sweden, on the influence of forests on climate. Dr. Ebermayer was the first, in 1866, to institute forest stations, and his work (*Die Physikalischen Einwirkungen des Waldes auf Luft und Boden* 1873) has from its appearance been the main source of information on forest climate. The present analysis is of considerable value, for in the twenty years which have elapsed since 1873 much important evidence has been collected and is here briefly discussed.—Bodentemperaturen zu Hamburg (Eimsbüttel) nach den von C. C. H. Müller in den Jahren 1886-91 angestellten Beobachtungen: von Dr. W. J. van Bebber (6 pp.). These observations were carried on by the late Herr C. A. H. Müller, and Dr. van Bebber has now discussed them.—Die mittlere Abweichung der einzelnen Barometerablesung vom Normalwerth und deren Verhältniss zur monatlichen Barometerschwankung: von Dr. W. Köppen (7 pp.). The subject of the

variation of barometer readings from the normal value has been treated by Buys Ballot in his *Afwijkingen* for a number of stations, and Dr. Köppen in this paper proceeds to supplement this by dealing with the data collected by the Deutsche Seewarte for the squares of the North Atlantic, for which it has published mean values. The variation is greatest towards Iceland, and the increase is double as rapid in summer as in winter, and it also increases from the ocean to the continents. Dr. Köppen concludes the paper with a comparison between the variation as he calculates it and the generally given figures of monthly barometer amplitude, and finds the proportion is nearly constant and is slight.—Ergebnisse der meteorologischen Beobachtungen der nederländischen internationalen Polar-Expedition 1882-83 in der Karna-See : von J. Hann (9 pp.). It is well known that Dr. Snellen and his party were caught in the ice and entirely prevented from landing. The observations were taken as best they could manage, drifting in the pack, and great credit is due to the party for what they succeeded in achieving. Curiously, another vessel with an expedition from Denmark, trying to get to Franz Joseph's Land, was also frozen up near them, and in her Dr. Snellen and his party sought refuge when their ship the *Varna* was crushed. We have, therefore, the records of two ships to compare with each other. Dr. Hann's paper gives a summary of the results.—Zum Klima von Sarona bei Jaffa: von Dr. C. Kassner (6 pp.). This is a collection of the data published by Mr. Glaisher in the quarterly statements of the Palestine Exploration Fund. The means for the ten years 1880-89 have been calculated and converted to metres and centigrade, and the results in figures are very useful, as the quarterly statements contain no figures of the results for a number of years.—Ueber die meteorologischen Beobachtungen auf den hawawaiischen Inseln: von Dr. A. Marcuse (3 pp.). This is an account of Mr. Lyons' publications. It appears that the government of Hawaii has 54 stations under Mr. Lyons, of which 16 are on Oahu, and 23 on Hawaii. Dr. Marcuse was himself a resident there for a year, and he collected such data as he could. The earliest observations in the group began in 1821, at the American Mission. Barometer readings began in 1837, and means for 17 years, 1873 to 1889, are given. The rain means for Honolulu are for 13 years, 1877-89.—Die neue Anemometer- und Temperatur-Station auf dem Obirgipfel (2140 m.): von J. Hann (10 pp.). The station Hoch Obir is one of the oldest mountain stations, starting from 1846, but it was 300 feet below the summit of the mountain. Now Dr. Hann has succeeded in organising an anemometer and thermograph station on the very top. The means for the whole period of activity of the station are now given, and special notes as to the diurnal variation of sunshine.

***Modern Meteorology*. An outline of the growth and present condition of some of its phases. By Frank Waldo, Ph.D. 1893. 8vo. 488 pp. and 112 illustrations.**

The object of this book is to bring the reader into closer contact with the work which has been, and is actually engaging the attention of working meteorologists, rather than to present finished results. The author, however, cannot have made himself familiar with English publications on meteorological subjects. If he had he would have found that he was appropriating for his book the title of a work published under the auspices of the Royal Meteorological Society in 1879, viz. *Modern Meteorology*, which contained the six lectures delivered before the Society in 1878 by Dr. R. J. Mann, Mr. J. K. Laughton, Mr. R. Strachan, Rev. W. Clement Ley, Mr. G. J. Symons, and Mr. R. H. Scott. It is true that the author states that living at a distance of several hundred miles from any considerable meteorological library, it was impossible for him to consult many original authorities, or to give a complete historical treatment of the various subjects ; but he must have known something of English meteorological publications, for in the preface he states that as there is no work published in English which gives an adequate description of meteorological instruments, he has given more prominence to this topic than would otherwise be warrantable.

The work is divided into six chapters. I. is mainly devoted to the mention of some of the principal sources of information concerning the progress of meteorological science ; II. contains a history and description of some important instruments and the methods of using them ; III. is mainly made up of an abstract of Dr. von Bezold's memoirs on thermodynamics of the atmosphere ;

IV. contains an outline of the history of the development of theories of the general atmospheric circulation ; V. is devoted to a historical sketch and partial explanation of the secondary atmospheric circulation to which the local character of winds can usually be referred, at least in the middle latitudes ; and VI. deals with applied meteorology.

Results of Rain, River, and Evaporation Observations made in New South Wales during 1891. By H. C. RUSSELL, B.A., C.M.G., F.R.S., Government Astronomer. 191 pp. and 8 plates. 8vo. 1893.

The number of rainfall stations in the colony is 1,215. The average rainfall for the whole colony for the year 1891 was 31·76 ins., or 28½ per cent. above the average of the previous 17 years. Heavy floods occurred in January, when the Darling River at Bourke rose to a height of 36 feet 2 ins., and the Barwon at Walgett rose to a height of 40 feet 2 inches.

Scottish Geographical Magazine. August 1893. Vol. IX. No. 8. 8vo.

This contains an interesting article "On Sunshine," by Mr. H. N. Dickson, which is based largely on Mr. Scott's pamphlet *Ten Years' Sunshine in the British Islands*, 1881-1890.

Symons's Monthly Meteorological Magazine. July-September 1893. 8vo.

The principal articles are:—The Drought of 1893 (9 pp.).—110 days of partial Drought. By P. Bicknell. The author states that the total rainfall at Beckenham from March 4th to June 21st was only 0·67 in. which fell on 16 out of the 110 days.—The summer of 1615. By C. M. Ainsley (1 p.).—Heavy rains following the drought (3 pp.).—Droughts in past years. By Harold Smith and Rev. J. Slatter.—The maximum temperature August 13th-18th, 1893 (3 pp.). During this period maximum temperatures of over 90° were registered over the greater part of the east of England.—Another eccentricity in London temperature (1 p.). A great difference took place in the minimum temperatures recorded in various parts of London during the early hours of August 18th, as is shown by the following:—Camden Square 64°·1, Greenwich 67°·3, West Kensington 71°·3, and Brixton 72°·0.—Extraordinary rainfall in a short period at Preston. By S. Wilson (2 pp.). During the severe thunderstorm which occurred on August 10th, 2·09 ins. of rain fell in 35 minutes from 4.5 to 4.40 p.m., and it is estimated that 1·25 in. of this amount fell in the 5 minutes from 4.29 to 4.34.—Sun-spots and air temperature (2 pp.).

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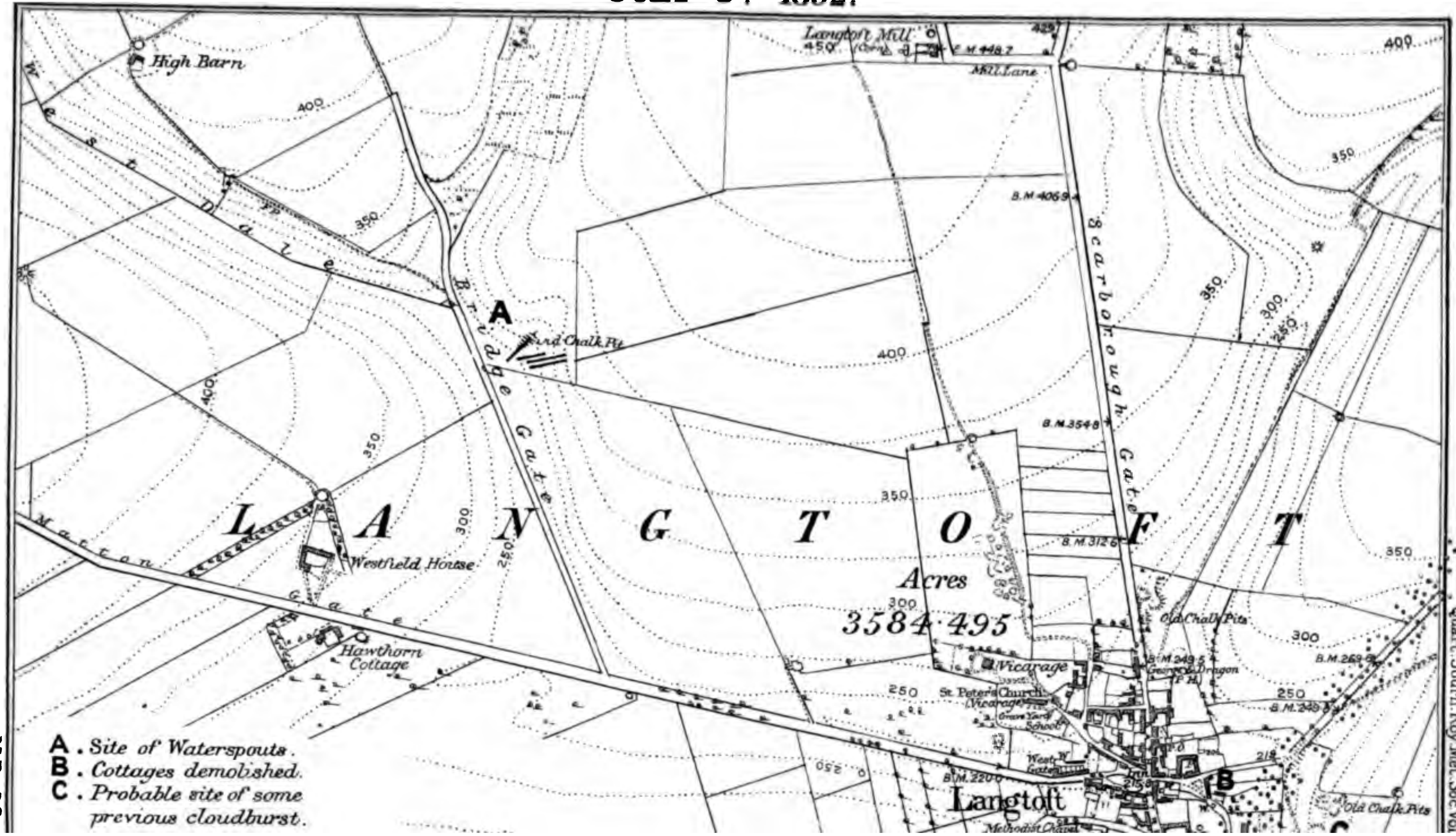
THE END.

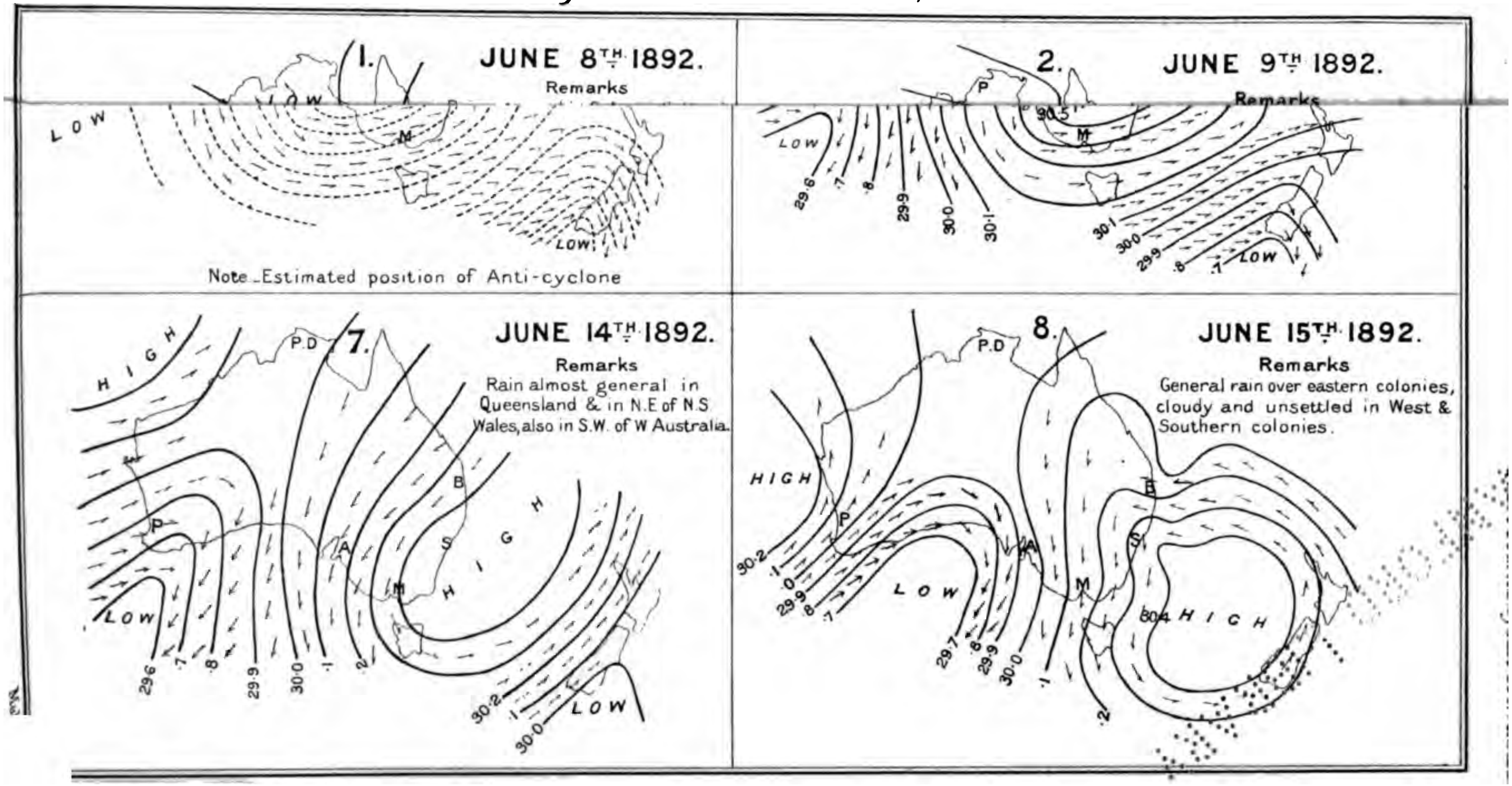
JULY 3rd. 1892.



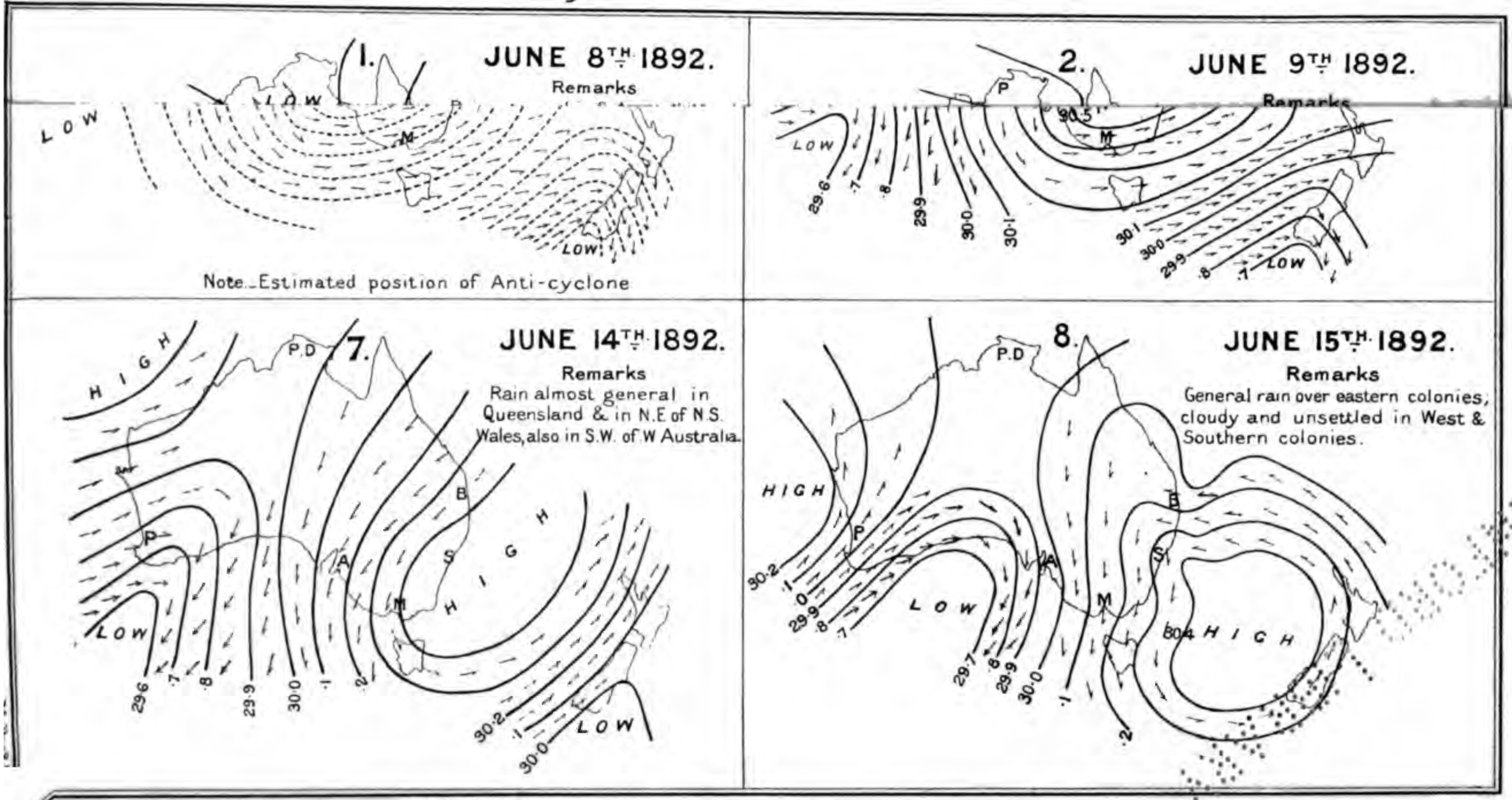
A. Site of Waterspouts.
B. Cottages demolished.
C. Probable site of some previous cloudburst.

Quart. Journ. Roy. Met. Soc. Vol

Anticyclone June 8th.-15th., 1892.



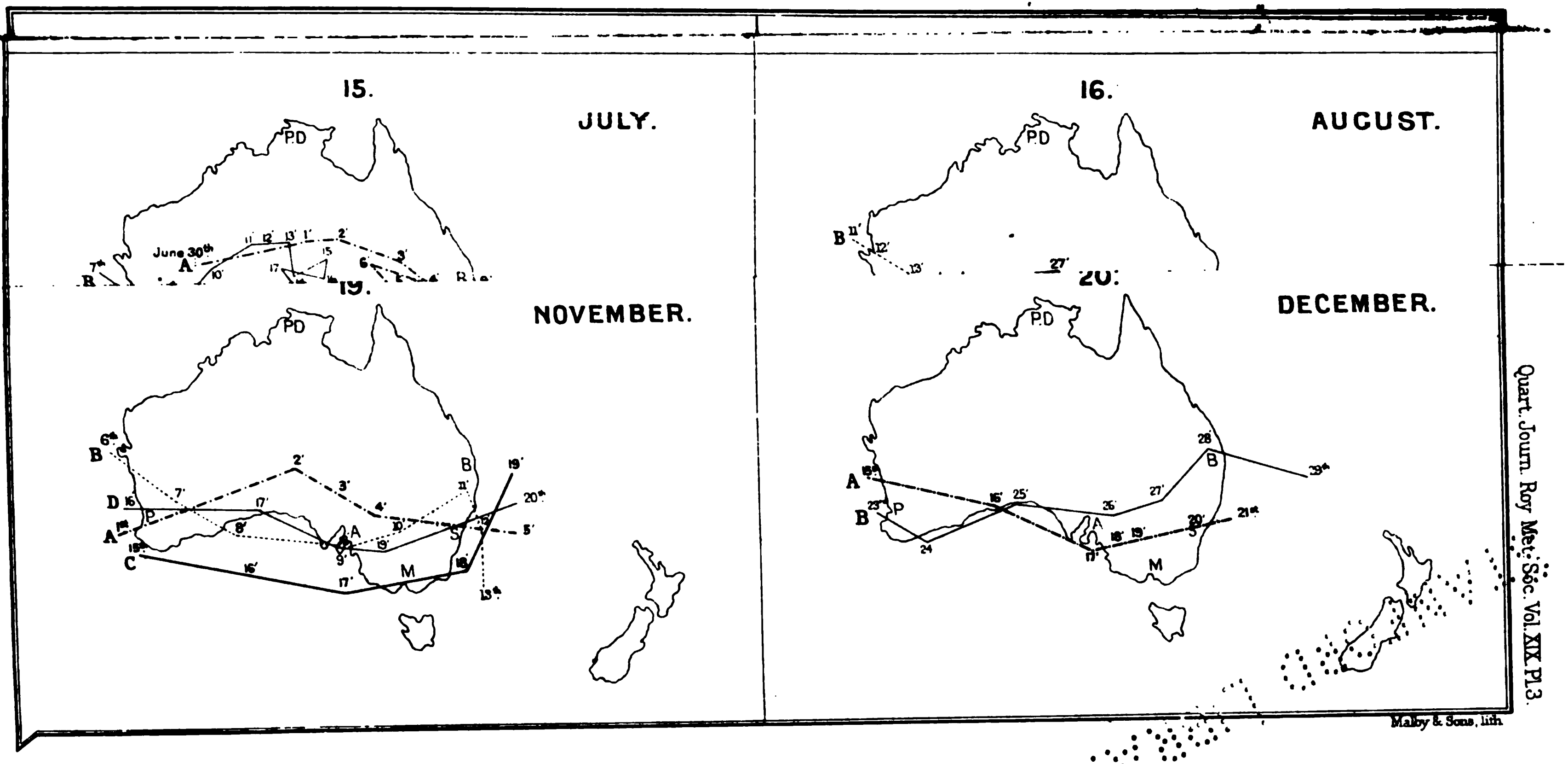
Anticyclone June 8th-15th, 1892.



Quart. Journ. Roy. Met. Soc. Vol. XIX.

MOVING ANTICYCLONES IN THE SOUTHERN HEMISPHERE.

Tracks of Anticyclones January - December 1891.



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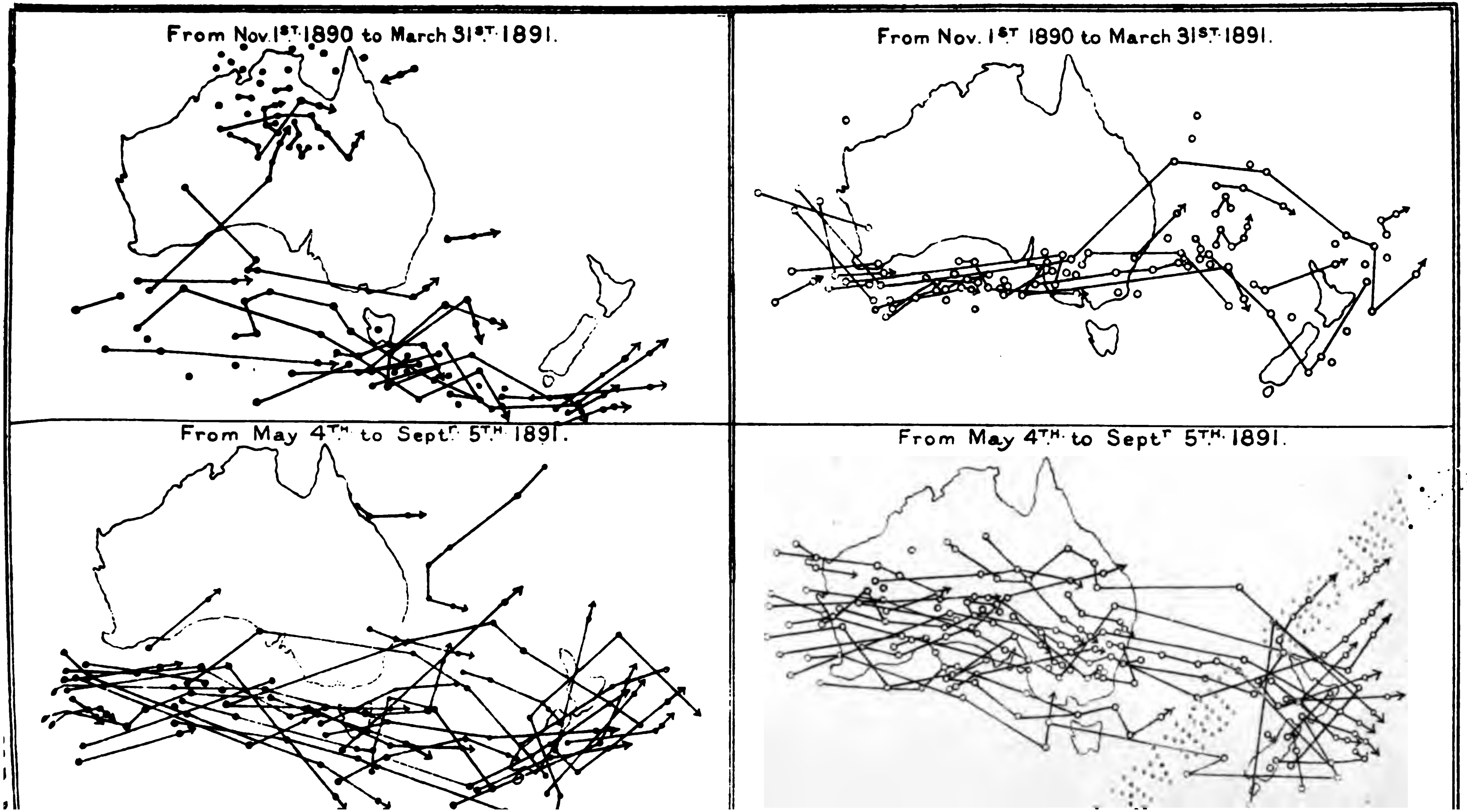

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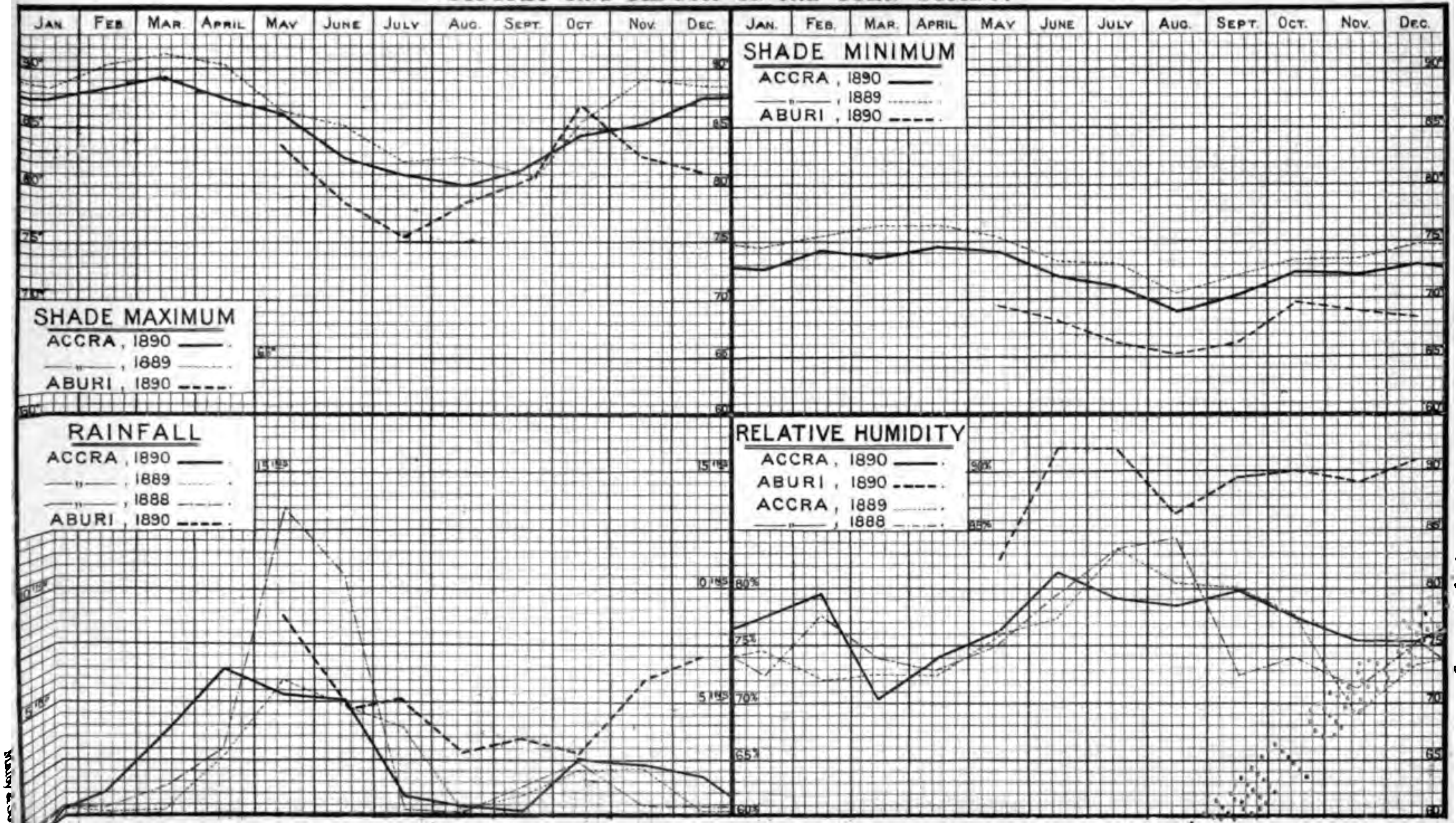
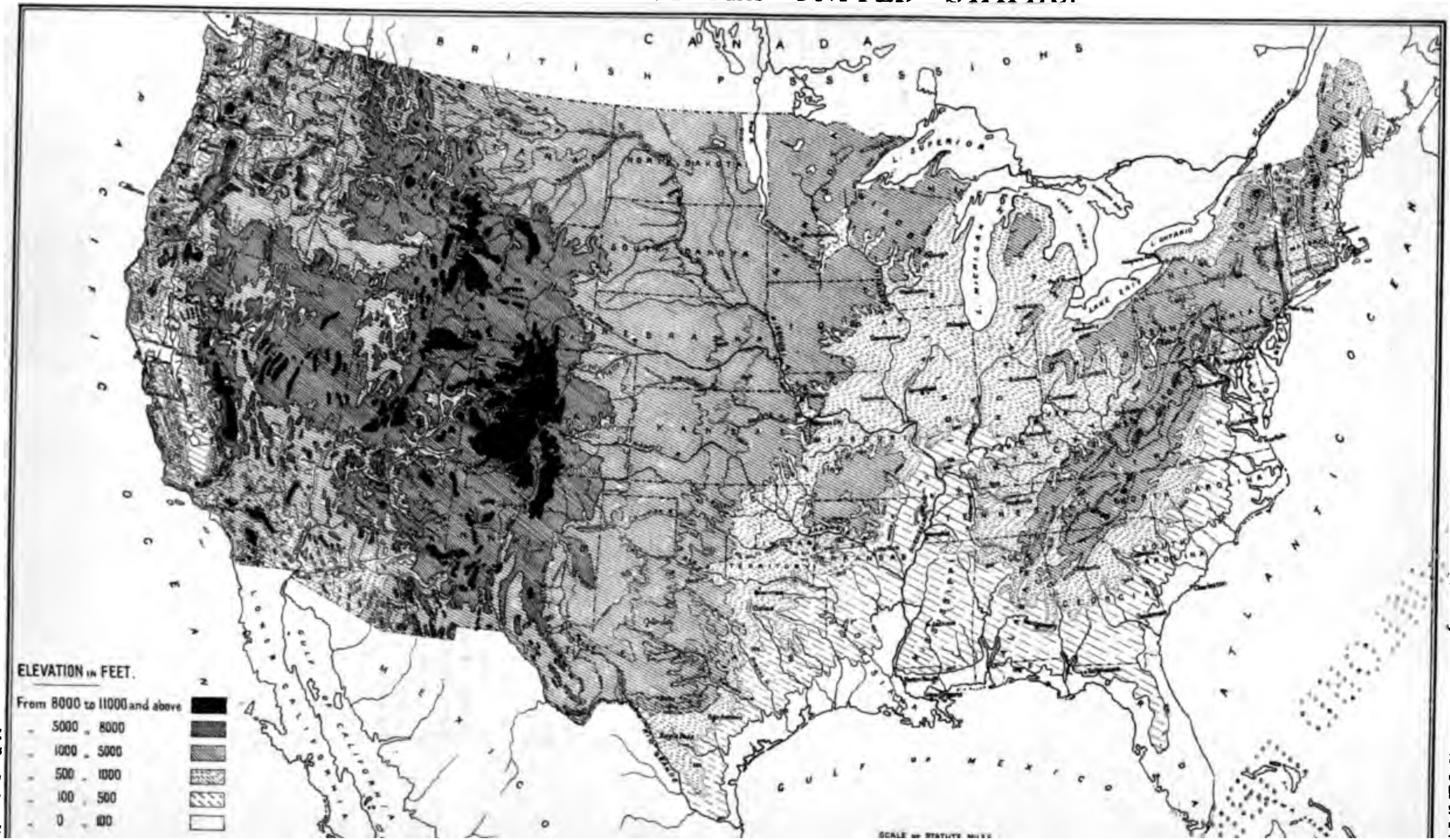


Quart. Journ. Roy. Met. Soc. Vol. XIX. Pl.

RELIEF MAP OF THE UNITED STATES.

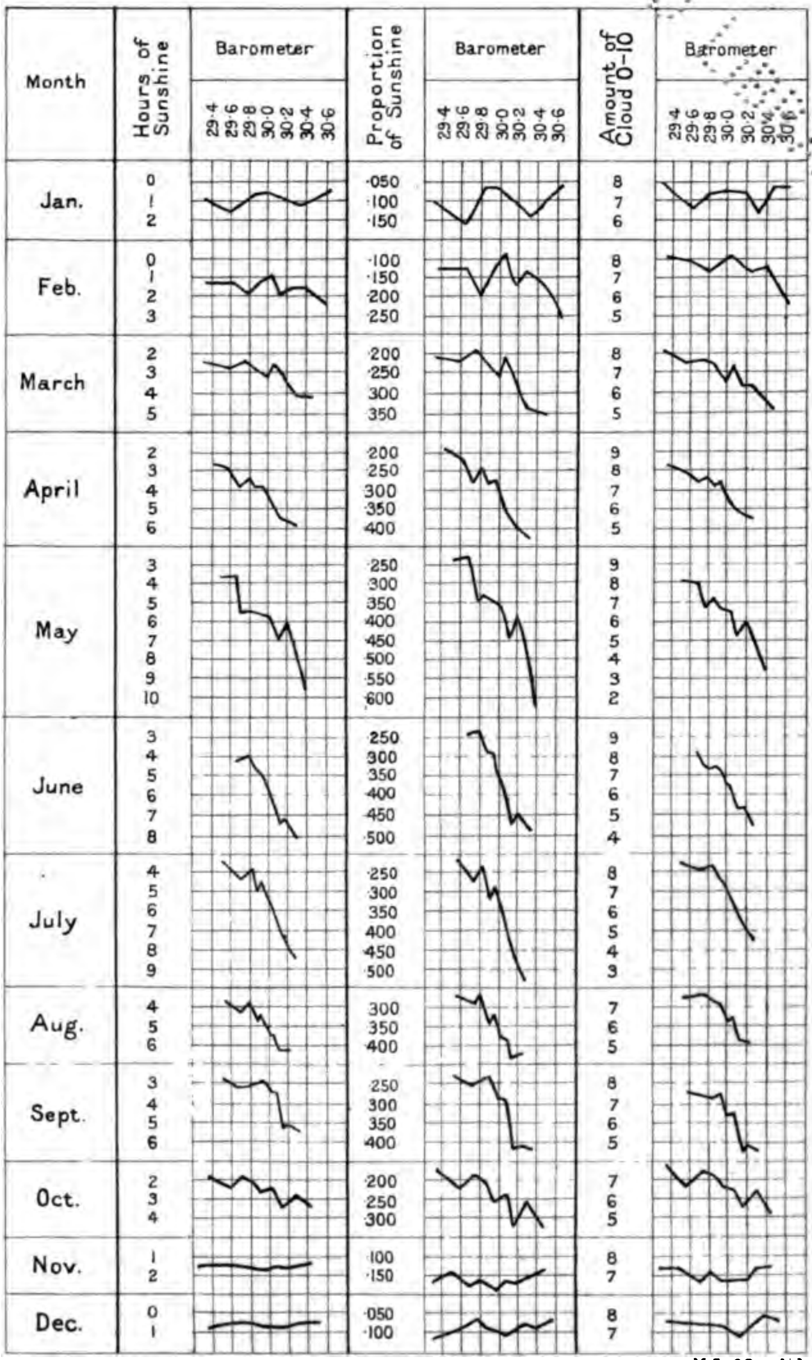


Mintern Bros. lith.

Quart: Journ: Roy: Met: Soc: Vol. XIX. Pl. 7.

ROYAL OBSERVATORY, GREENWICH.

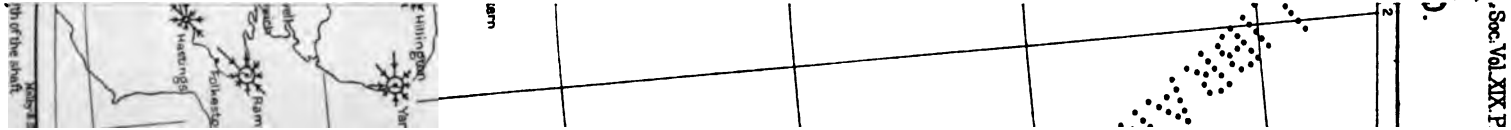
Curves showing the relation between the duration of Sunshine and amount of Cloud, and the height of the Barometer, for different months, from the observations and records of the years 1877-1891.



The barometer values are reduced to mean sea level.

Malby & Sons. Lith.

PERCENTAGE OF WIND DIRECTION, 1876–80.



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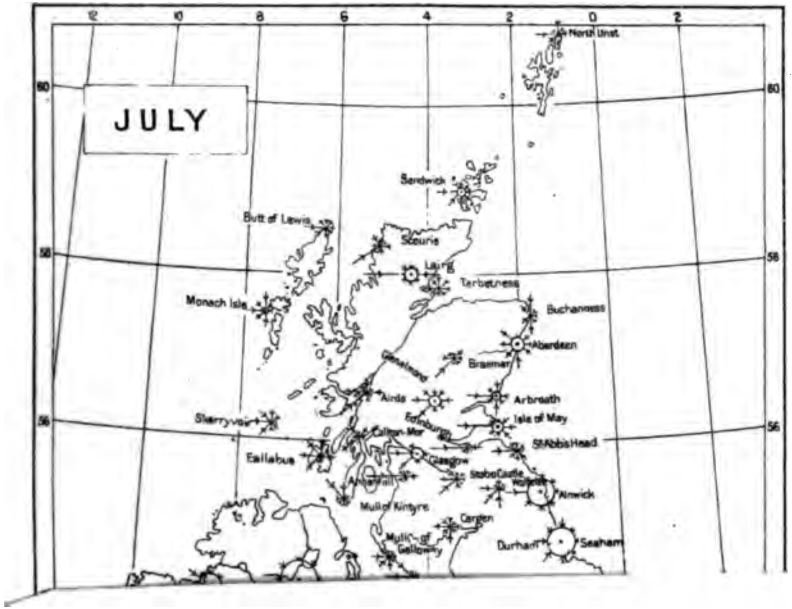

Quart. Journ. Roy. Met. Soc. Vol. XIX. Pl. I

PERCENTACE OF WIND DIRECTION : 1876 - 80.

Note. The circles denote the percentage of Calms, the arrows fly with the Wind, and the percentage of Direction is shown by the length of

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MEZZANINE